PRACTICAL ENGINEER

Trade-mark reg. U. S. Pat. Office

SEMI-MONTHLY

VOL. XIX. CHICAGO, MARCH 1, 1915 No. 5

The Marseilles Development

FREQUENCY CHANGER PROVIDES FLEXIBILITY OF OPERATION OF 25 AND 60-CYCLE GENERATORS; DOUBLE SWITCHING APPARATUS INSURES CONTINUOUS SERVICE

IN ORDER TO take advantage of the water power furnished by the Illinois-Michigan Canal at Marseilles, Ill., the Northern Illinois Light & Traction Co. purchased the right to use this water at a fixed rate per year, the charges being based on the size of intake opening. Engineers working on this project determined that, with the available head, sufficient energy could be generated not only to supply the Illini Trail System running from Princeton to Joliet with power for traction, but also enough to furnish Marseilles and surrounding towns and villages with light and power.

FIG. 1. STEAM AND HYDRO-ELECTRIC PLANTS AT MARSEILLES, ILL.

After the plant was in operation, it was found, due to the variable flow of water and trouble encountered with ice, that a supplementary steam plant was necessary. As a result, a turbine plant has recently been installed with a temporary building to house it until its final size is determined and steel and concrete walls can be built.

As shown in Fig. 1, the hydro-electric station consists of a low steel structure faced with rough red and cream brick resting upon concrete arches and piers. A wing extending to the north contains the entire electrical control and switching apparatus, while all generating machinery is housed in the main building.

For convenience in handling heavy machinery, provision is made to allow a standard size freight car to enter the west end of the building. And as a further aid, the station is equipped with a 20-ton, double-girder Case electric crane with floor control.

As shown in Fig. 7, a concrete forebay and sluice divert the head waters to the north side of the station, while ice booms and trash racks of special designs tend to keep the wheel pits clear.

This boom is built up of 11 sections, consisting of 2 12 by 8-in. timbers chained together and held in place by 1-in. U bolts encircling 8-in. iron pipes, filled with and imbedded in concrete and spaced at 25-ft. intervals. To allow for necessary play and at the same time prevent ice from passing between the sections, a joint, shown in Fig. 6, is used.

With the ordinary trash rack built up of rectangular bar sections, it was found that as the water passed between the bars considerable contraction took place, tending to retard the flow. To overcome this difficulty, a special section, shown in Fig. 5, was designed and is now in use. Eleven of these sections separated by cast-

iron spacers are built up into units measuring 2 ft. 5/8 in. by 16 ft. and are held together by 5 1½ by 24⅝-in. round iron rods.

All surplus water, ice and trash are diverted over a spillway under the west end of the building.

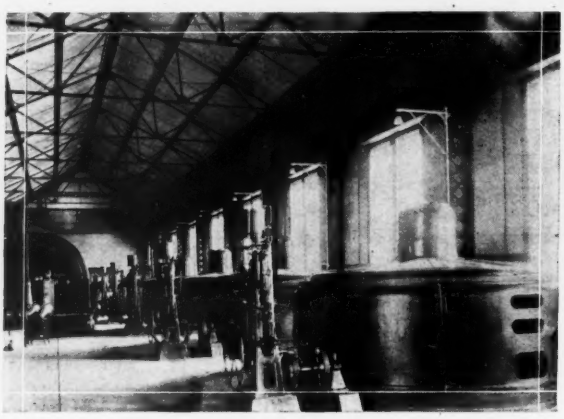


FIG. 2. HYDRO-ELECTRIC GENERATING ROOM

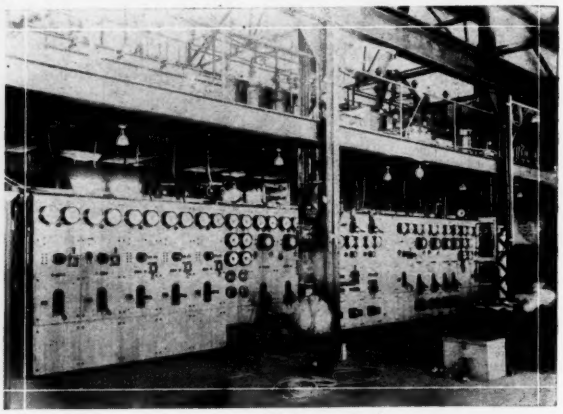


FIG. 3. SWITCHBOARD AND GALLERY

Each wheel is in a separate compartment provided with heavy iron gates which, when closed, prevent the further flow of water and render the pit accessible for inspection and repairs.

Generating Equipment

At the east end of the station are 2 sets of 3 wheels each connected through bridles to alternators, one a 500-kw., 60-cycle Westinghouse, and the other a 450-kw., 25-cycle General Electric machine. Placed next to these are 2 90-kw., 125-v. Westinghouse exciter units, each direct connected to a vertical water wheel. The remaining units are 6 Westinghouse vertical water-wheel generators of the revolving-field type, each rated at 350 kw., 2 at a frequency of 25 cycles, 4 at 60 cycles. Each wheel is equipped with a Lombard, type Q, governor carrying a pilot valve and controlling Leffel gates by oil pressure furnished by belted pumps.

In addition are installed one Westinghouse motor-generator exciter consisting of a direct-current generator rated at 100 kw., 125 v., and driven by a 100-hp., 2200-v., 60-cycle induction motor at 530 r.p.m., and one 750-kv.a., 2300-v., 3-phase frequency changer, changing from 25 to 60 cycles or reverse as required.

Switch and Control Equipment

Cables connecting the various machines to their respective switchboard panels are carried through conduits in concrete trenches to hand-operated oil-break switches at the rear of the board.

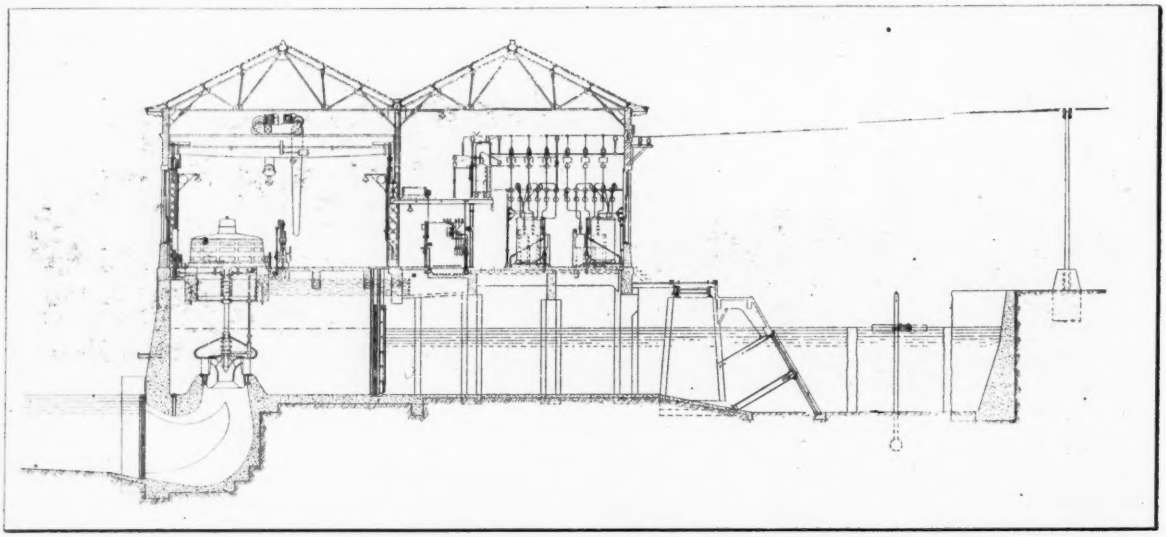


FIG. 4. CROSS-SECTIONAL VIEW OF HYDRO-ELECTRIC STATION, SHOWING ICE BOOM, TRASH RACK, SWITCHING COMPARTMENT, WATER WHEELS AND GENERATORS

In order to insure continuity of service, everything between these switches and transmission lines is in duplicate. Four sets of bus bars, one main and one emergency set for each frequency are provided with additional duplicate sets of oil circuit breakers, disconnecting

switches, transformers, choke coils and lightning arresters. The flexibility of this arrangement may readily be understood by referring to Fig. 8. With this scheme of connections it is possible to operate from either set of buses and feed into 2 separate outgoing circuits or, by means of disconnecting switches and oil circuit breakers

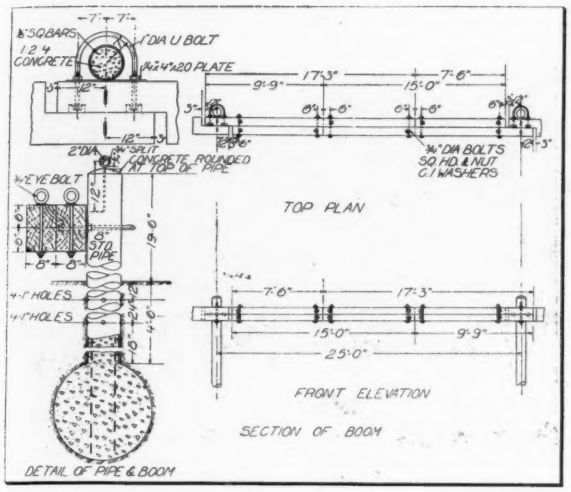


FIG. 6. DETAILS OF ICE BOOM AND BOOM PIPE

the 2 circuits may be tied together, allowing one side or other of the switching equipment to be cut out for necessary inspection or repairs.

Four separate sets of high-tension lines leave the station. These consist of 2 25-cycle sets and 2 60-cycle sets, one of each being carried east and one of each west. The 25-cycle service, used for power, is distrib-

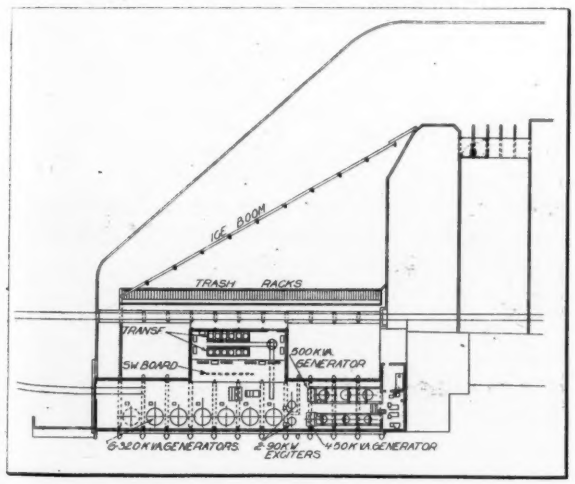


FIG. 7. PLAN SHOWING CONCRETE FOREBAY, SLUICE, ICE BOOM AND TRASH RACKS

uted to the traction system at Morris and Ottawa, while the 60-cycle lines carry the lighting loads of the surrounding towns and villages.

All 2300-33,000-v. transformers, low and high-tension bus wires, disconnects, oil breakers and coils are placed back of the switchboard, while on the gallery above are lightning arresters, rheostat grids, totalizing watthour meters for 60 and 25-cycle service and a tub transformer and panel for the Marseilles street lighting system.

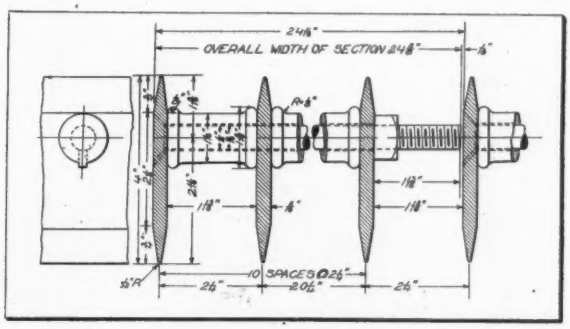


FIG. 5. SPECIAL BAR SECTIONS FOR TRASH RACKS

All transformers are of the water-cooled type and are placed on 4-wheel trucks which, in case of repairs, may be run onto a transfer car and wheeled out under the crane.

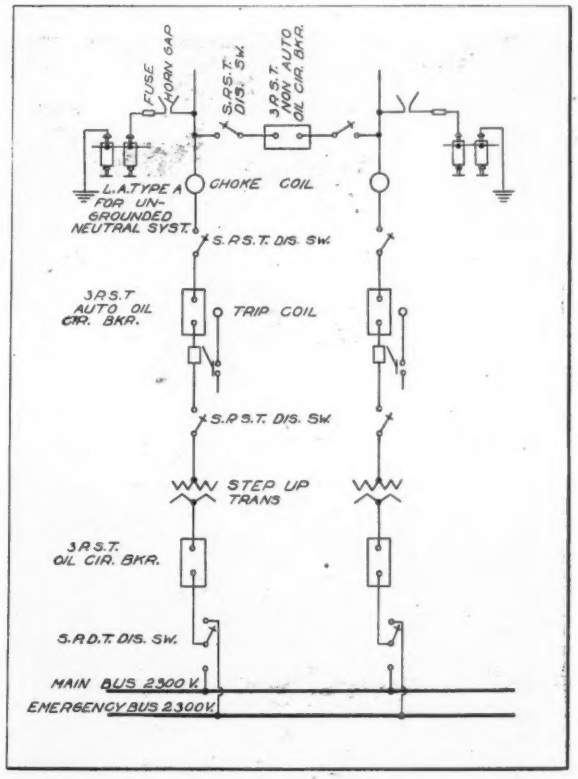


FIG. 8. SINGLE LINE DIAGRAM OF CONNECTIONS OF SWITCHING APPARATUS

Station voltage regulation is secured by 2 Tirrill regulators, one for each frequency.

Auxiliary Equipment

In addition to lighting the streets of Marseilles, the Northern Illinois Light & Traction Co. supplies the city

with water by means of 3 Smith-Vaile triplex pumps, 2 of which are geared to 40-hp., 2200-v., 3-phase, 60-cycle induction motors, while the third is operated by a

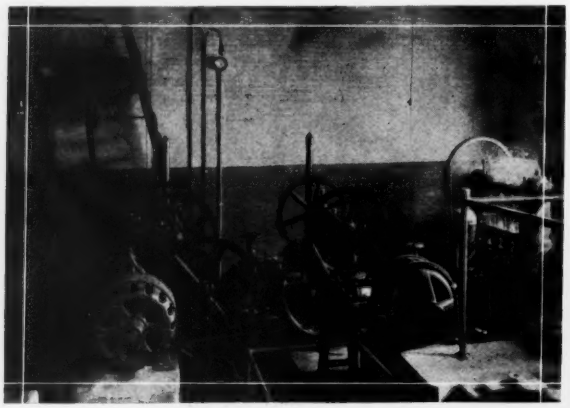


FIG. 9. MOTOR DRIVEN PUMPS FOR MARSEILLES WATER WORKS SYSTEM

50-hp., 2300-v., 3-phase, 60-cycle induction motor, delivering the water to a standpipe on a hill above the town. The pumping plant is shown in Fig. 9.

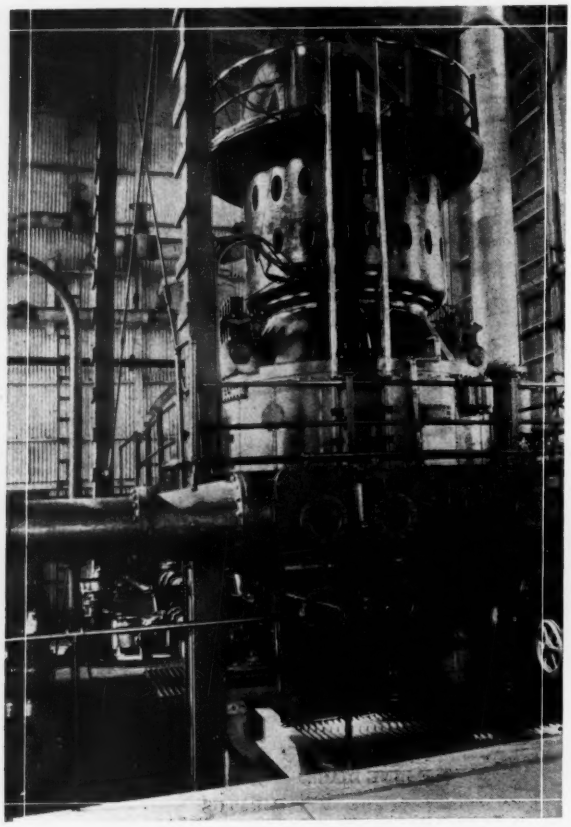


FIG. 10. 2000-KW. GENERAL ELECTRIC STEAM TURBINE

During the cold season, the station is heated with steam supplied by a Kewanee low-pressure boiler to radiators placed under each window.

AUXILIARY STEAM PLANT

WHEN IT became evident that the continuous operation of this station was jeopardized by the great ice floes occurring every spring, an auxiliary steam plant, shown at the left of Fig. 1, was built. Although the machinery now contained in this building is permanently installed, the housing is but temporary, being a frame of wood with corrugated steel sides and composition roof.

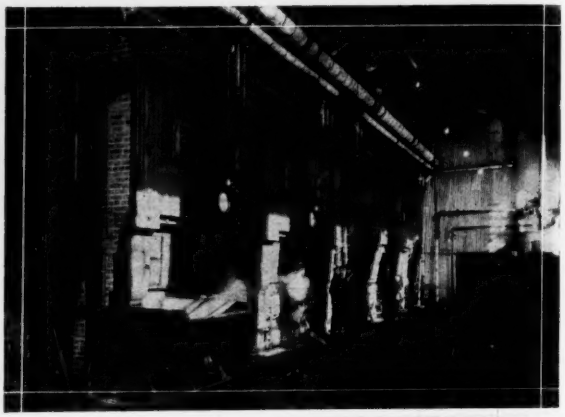


FIG. 11. BOILER ROOM, MARSEILLES STEAM STATION

The boiler-room equipment consists of 6 Stirling water-tube boilers arranged in 3 batteries of 2 250-hp., 2 285-hp., and 2 400-hp. units, operating under a pressure of 150 lb.

All boilers are hand fired from the floor with coal dumped in front of them brought in by industrial cars or thrown in through the windows alongside.

Ashes are removed through the pit doors, shoveled into industrial cars and wheeled out.

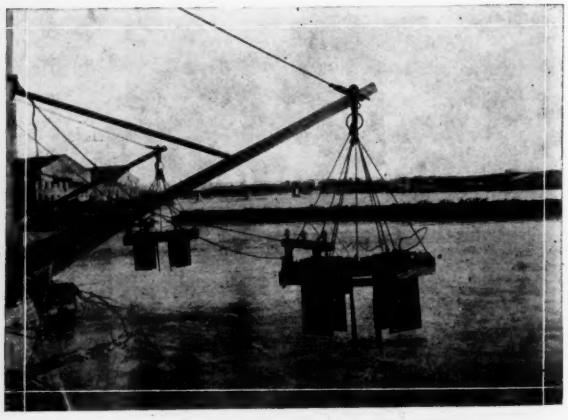


FIG. 12. WATER RHEOSTAT USED FOR STATION TESTS

Water fed to the boilers is heated in a No. 4 Stilwell feed water heater which takes steam from the various auxiliaries and is supplied with an Erwood relief valve exhausting all excess steam into the atmosphere.

Most of the auxiliaries, except the feed water heater and house pump, are placed in the turbine room, which also contains a 2000-kw., 2300-v. Curtis vertical con-

densing turbine and a 35-kw., 125-v. Curtis horizontal turbine exciter unit.

A 2-panel board for the control of these 2 machines is placed at the east end of the room. By means of a switch on the exciter panel, the fields of the steam turbine may be energized by either the turbine-driven exciter or those in the hydro-electric station, while the generator, through a hand-operated oil switch on its panel, connects directly with the 25-cycle bus bars in that building.

Testing Equipment

Tests may at any time be made on any one of the station units by means of the water rheostats shown in Fig. 12. As may be seen, these rheostats are built up of iron plates attached to a wooden frame and so arranged that they may be lowered into the waters of the tail race to create a desired load. From tests already carried out, it has been found that these rheostats are capable of carrying a load of 2600 kw. at a voltage of 2300.

The Barometer of Power Plant Economy

Comparison of Coal Consumption and Power Output. By Reginald Trautschold

WHEN it comes right down to common, everyday facts, efficiency in power plant production means to the management, the greatest number of horsepower-hours obtained from the coal pile for the fewest number of dollars, while suitably maintaining power supply for all requirements. It is really economy in power production that is of main interest, not efficiency in power production. Be that as it may, the conditions governing efficiency and economy in power production differ in one main respect only; the former being governed by the amount of steam generated by a given weight of coal and the latter depending upon the number of pounds of steam generated for the least expenditure for fuel, labor, etc. Subsequent operations in the conversion of the steam into useful mechanical power affect similarly both economy and efficiency.

Pounds of water evaporated per pound of coal, or pounds of water evaporated for a given outlay, at the boiler and the pounds of steam consumed per horsepower, or other power unit, at the engine or turbine are then the important considerations in any steam power house. Inefficiencies may occur after the steam has been delivered to the power unit; but such are comparatively easily located, if not simply remedied, and if the prime mover is efficient and kept in good working order, indicator cards will accurately show the consumption of steam. Rate of evaporation is just as easily ascertained, being accurately measured by the amount of water fed to the boiler. The 2 most important facts pertaining to both economic and efficient operation are thus easily discovered.

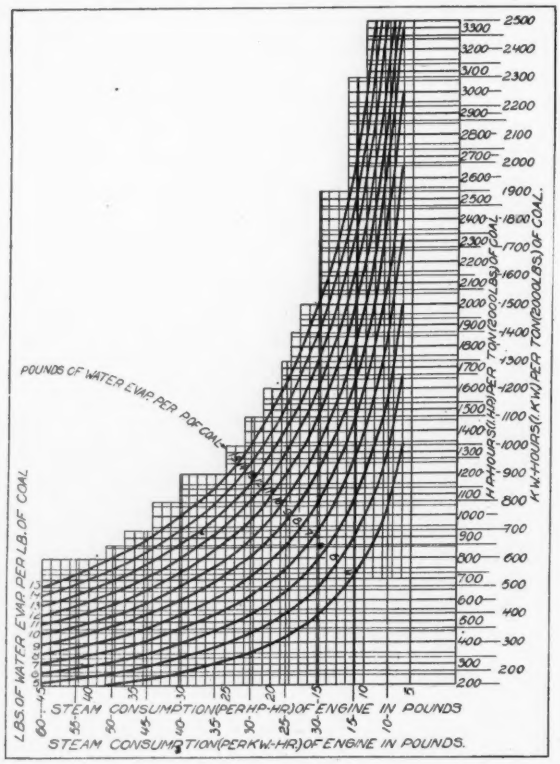
Every coal having its own particular value as a steam producer under a given boiler, a value that is not necessarily entirely dependent upon its heating value, the rate of evaporation may differ for nearly every coal. Steam consumption, on the other hand, is a fairly constant quantity if the engine room equipment is kept in efficient operating shape. The aim of every operator of a steam power plant is then to secure the maximum evaporation for the least money, whether that means the maximum evaporation per pound of coal or not.

Economic choice of coal for any plant must be largely a matter of experiment; but once the right coal has been selected, the economic generation of power is dependent upon the efficiency of production. Knowing the steam consumption of the power unit and having ascertained the rate of evaporation by a careful test under good working conditions, the efficiency of the combined boiler and engine plant is a simple calculation—the steam consumption divided by the supply of steam, or amount of water evaporated. The rate of steam supply should be reflected by the speed at which the coal supply is consumed, which, if it were not for the losses between the boiler and the power unit, would also accurately indicate the rate of evaporation. With the coal pile thus acting as a gage for measuring both the economy of steam generation and the efficiency of steam consumption, it serves as an excellent means of locating leaks and losses—particularly to the accounting department.

The losses between the boiler and the engine can usually with care be kept down to a small amount—an amount that is quite inconsequential as far as the practical efficiency of the power plant is concerned, so that if there is any marked variation between the consumption of coal as indicated by calculations based on the rate of evaporation at the boiler and that based on calculations from the indicated steam consumption of the power unit, it is proof positive that some preventable losses are taking place. Such calculations, however, require considerably more time for their solution than the reading of a chart graphically depicting the results—such chart being easily evolved—besides which the impossibility of reading a chart to the same degree of accuracy as may be obtained by the use of figures is rather a practical advantage than a handicap, the error in reading compensating for the slight unavoidable loss between the boiler and the engine. For these reasons, the accompanying chart, showing the horsepower-hours per ton of coal at various rates of evaporation, proves of considerable assistance to the management of a plant in locating inefficiencies in plant operation, reduced efficiency of boilers, unsatisfactory operation in the boiler room, etc., as well as in discovering wastes due to carelessness in handling fuel and other losses that the most careful and elaborate boiler and engine tests can no more accurately ascertain—theft of coal, for instance.

As a typical example, a simple 300-hp. Corliss engine may be considered, that was purchased on a guaranteed steam consumption of 18 lb. under usual conditions of service. A careful boiler test has shown an average rate of evaporation of 9 lb. of water per pound of fuel. Furthermore, these records have been pretty uniformly attained during the first weeks of operation when it is

discovered that coal is being furnished the boiler room at a rate of 6 tons per day of 10 hr. operation. Referring to the chart, it is seen that a ton of coal burned so as to develop 9 lb. of steam per pound of fuel for an engine consuming 18 lb. of steam per i.hp.-hr. should be good for 1000 hp.-hr., or the necessary amount of coal for the boilers should not greatly exceed 4 tons per day. A discrepancy of 50 per cent could not be charged to the loss between the boiler and engine. Calibration of the indicator cards would fix the steam consumption of the engine and if these proved satisfactory and no evident wastes were found to be occurring in the connections to the boiler—a hasty examination of the piping, valves, etc., being ordinarily all that should be required—the waste would probably be found in the boiler room.


POUNDS OF WATER EVAP. PER POUND COAL
LBS. OF WATER EVAP. PER LB. OF COAL
H.P.-HOURS PER TON (2000 LBS.) OF COAL
K.W.-HOURS (K.W.) PER TON (2000 LBS.) OF COAL
STEAM CONSUMPTION (PER H.P.-HR.) OF ENGINE IN POUNDS
STEAM CONSUMPTION (PER K.W.-HR.) OF ENGINE IN POUNDS.

HORSEPOWER-HOURS PER TON OF COAL AT VARIOUS RATES OF EVAPORATION

The leak would be ascertained but not necessarily located or discovered, for, not infrequently, a boiler test would show nothing radically wrong. Nevertheless, wastes have been occurring—possibly before the coal ever entered the boiler room, or more probably through careless firing or clever concealment of wastes by the boiler room force, wastes that may not be at all apparent while a boiler test is being conducted. Or the increased cost of power might be due to the fact that a poorer grade of coal was being supplied, a fact that would be more accurately discovered by the chart investigation than by analyses of samples of the coal that may or may not be typical of the whole mass of coal.

Of course, such wastes could all be run to ground by careful tests of the power plant and insistence that the same care be taken in daily operation as when conducting such tests, but these tests are not only quite expensive to conduct and should be of considerable duration to be truly typical of operating conditions, but they cannot be of daily occurrence. Maintaining the test standard every day is also no easy task. The chart alone cannot accomplish all these desired results, it is true, but it does furnish a handy means of checking up the efficiency of operation at any time. More or less calculations based on the data from indicator cards and the record of feed to the boiler would serve just as well, of course, but such calculations are not apt to be made as frequently nor by as many people as would use the chart. With the chart, the management, the superintendent, the accounting department and the boiler room force can readily ascertain the comparative economy of operation of the plant whenever desired—particularly the fireman. The latter, in the average efficiently operated plant, probably takes more pride in his department than anybody else. He wants to know the best and easiest way to perform his duties, and this is invariably the most efficient way. Let him know just how efficiently he is working. The oftener this information is supplied the better.

Automatic recording devices for the feed supply to the boilers and the coal consumption, with frequent use of such a chart as presented, converts the coal pile into a readable as well as most practical barometer of economy in power production. If, in addition, a continuous power load record is kept, accounting with all its value in cost keeping is not only greatly simplified but made much more accurate.

Extinguishing Liquid Fires

ACCORDING to Edward A. Barrier, the only principles which can be made use of in extinguishing fires in volatile oils are (1) to form a blanket of either gas or solid material over the burning liquid, which will cut it off from the oxygen of the air or, (2) to dilute the burning liquid with a noninflammable extinguishing agent miscible with it.

In a paper presented to the American Society of Mechanical Engineers the above-named author said that sawdust is specially efficient in extinguishing liquid fires, as it forms a blanket which for a time floats upon the surface of the liquid, excluding the oxygen of the air. The efficiency of sawdust is greater on viscous than on thin liquids, as it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when ignited, it burns without a flame and the burning embers have not sufficiently high temperature to reignite the liquid. Mixing sodium bicarbonate with the sawdust increases its efficiency materially.

Carbon tetrachloride has received recently considerable attention as a fire extinguishing agent. If pure, the water-white liquid has a rather agreeable odor not unlike that of chloroform; its specific gravity is 1.632 at the melting temperature of ice. It is noninflammable, nonexplosive and mixes readily with oils, waxes, japan, etc. The vapor is heavy, having about 5½ times the weight of air so that it forms a blanket of noninflammable gas over the burning liquid which excludes the oxygen of the air necessary to the process of combustion.—Safety Engineering.

Drainage of Low-Pressure Piping

By Charles L. Hubbard

LOW-PRESSURE drips commonly include the drainage from exhaust pipes, oil separators, feed water heaters, receiver barrels and exhaust heads. The condensation may be either oily or practically free from oil, depending upon the point from which it is taken.

In general, low-pressure drips contain oil and no attempt is made to save them, although the heat is sometimes utilized for heating the feed water when the exhaust steam is not sufficient for all heating require-

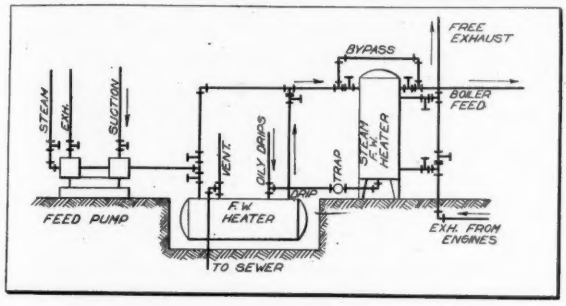


FIG. 1. METHOD OF UTILIZING HEAT FROM OILY DRIPS

ments. An arrangement for this purpose is shown in Fig. 1, and consists of an ordinary closed feed water heater so arranged that the oily drips pass through the tubes on the way to the sewer, while the feed water is pumped through the shell. Such a heater may sometimes be used separately or in series with a steam heater, as shown, the connections being so made that each may be operated independently of the other.

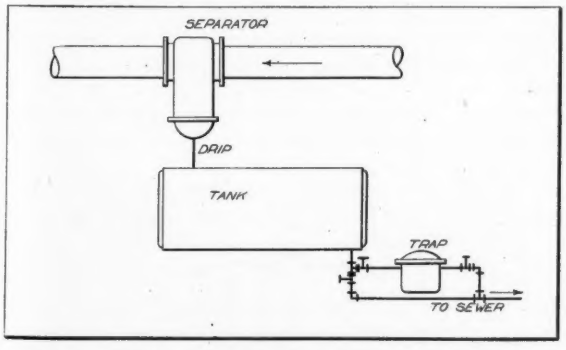


FIG. 4. CONNECTIONS TO DRIP TANK AND TRAP

All drips should be cooled to 100 deg. or below before discharging into a sewer, hence, if the cooling process may be turned into a saving, it should always be done, or at least considered, in order to determine its practicability in any given case. Drips from oil separators, also exhaust mains and feed water heaters located between the engines and oil separators, are commonly turned into the sewer without any attempt at purification.

Exhaust steam which is turned into a surface condenser or heating system should always first be purified, as the coating of oil which accumulates on the interior surfaces prevents the free transmission of heat through condenser tubes and radiators. Furthermore, oil should be rigidly excluded from water returned to the boilers, as its presence not only reduces the heat transmission through the heating surfaces, but is liable to cause burning of the plates, to assist in the formation of hard scale and to produce foaming.

Removal of Oil from Exhaust

The simplest and most common method of removing oil from steam is by the use of an oil separator similar in construction to those employed for the removal of moisture.

To prove efficient, separators of this kind must be properly proportioned to their work in order to limit the velocity, and usually require a straight run of pipe the full size of the port opening 5 or 6 diameters in length immediately preceding the separator when the

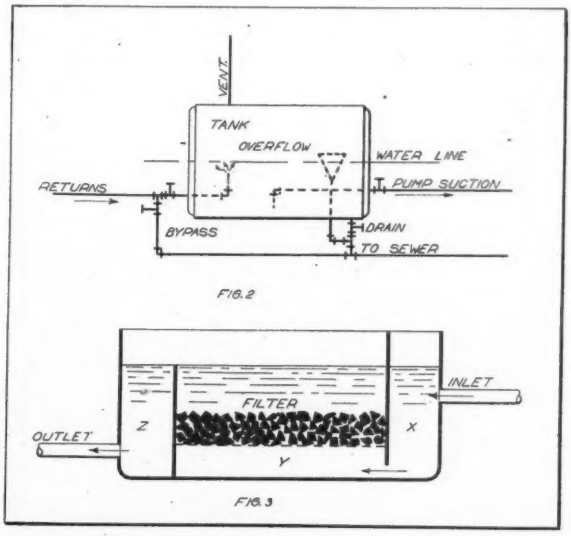


FIG. 2. SETTLING TANK FOR THE REMOVAL OF OIL

FIG. 3. SETTLING TANK AND FILTER

latter is made larger than the main with which it connects. The size of separator should always be determined by the makers for the quantity of steam which is to pass through it and this often calls for a larger size than the main, especially in the case of exhaust steam heating.

In case sufficient oil is found to pass the separator to affect the boilers, it will be necessary to purify the condensation either by filtration or the use of a separating tank in which the oil is allowed to rise to the surface, from which it may be drawn off from time to time. A simple form of settling tank is shown in Fig. 2. This may be constructed of a standard cast or wrought-iron blowoff tank connected up as indicated in the cut.

When a sufficient layer of oil has collected on the surface of the water, the connection with the feed pump may be shut off and the water and oil allowed to overflow into the sewer until the surface is cleared.

A combined settling tank and filter is shown in Fig. 3. This is best constructed of light boiler iron and may be made rectangular in form with 2 partitions, as indicated. Condensation enters at the right, most of the oil rising to the surface in compartment X, while the water passes into Y through on opening near the bottom. From here it rises through a coke filter and overflows into compartment Z, which has a pump connection near the bottom. Any oil which finds its way past compartment X and the filter, rises to the surface in Y and Z and may be drawn off from time to time in the same manner as described in connection with Fig. 2.

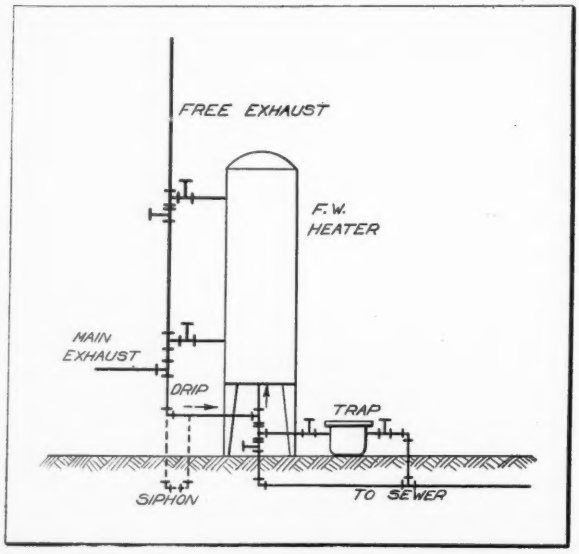


FIG. 5. METHOD OF DRAINING EXHAUST RISER

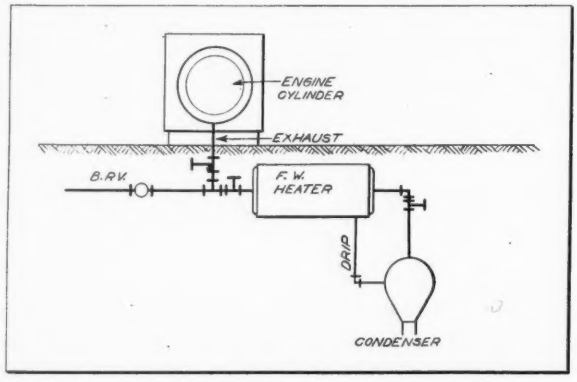


FIG. 6. DRIP CONNECTION FOR VACUUM HEATER TO CONDENSER

The drip connection from an oil separator, which drains a main exhaust line taking exhaust steam from 2 or more engines, should first lead to a reservoir or tank before passing to the trap. The reason for this is, that when steam is first turned into the system, or a cold engine is cut into service, the amount of condensation is temporarily increased beyond the capacity of the trap, thus partially flooding the separator and allowing a certain amount of oily water to pass into the heating system or condenser. A tank of sufficient size placed as shown in Fig. 4, will catch any sudden rush of water, thus equalizing the work of the trap and preventing any overflow into the system beyond the separator.

Drainage of Feed Water Heaters

Drainage of feed water heaters is an important item in connection with a low-pressure or exhaust system of piping. A common method of draining an outbound exhaust riser and a closed heater in a noncondensing system is shown in Fig. 5. With this arrangement, there is danger of a slight drop in pressure in the heater, when working at maximum capacity, which is often sufficient to cause short-circuiting through the drips as indicated by the arrows. This prevents the condensation from entering the trap and results in a partial flooding of the heater.

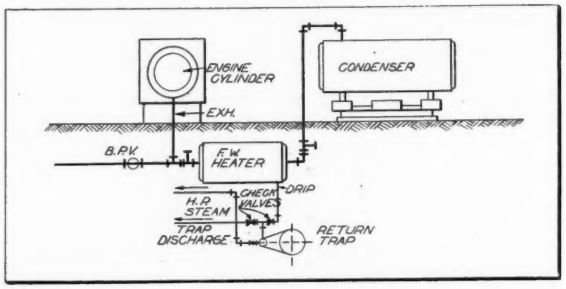


FIG. 7. METHOD OF DRAINING VACUUM HEATER LOCATED BELOW THE CONDENSER

This condition may be avoided by making a siphon loop 3 or 4 ft. in length of the drip from the exhaust riser, as shown by the dotted lines, or, if there is not sufficient space for this, a special trap may be used.

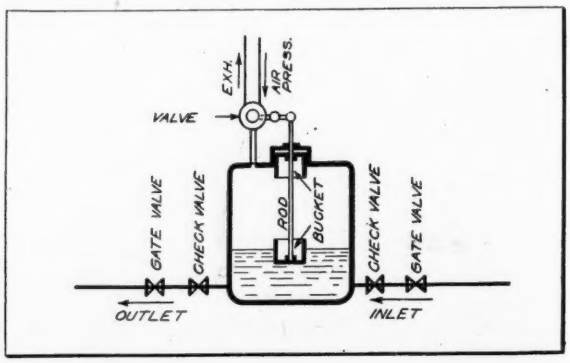


FIG. 8. PNEUMATIC EJECTOR FOR LIFTING SEWAGE

In many condensing plants, the exhaust from the various pumps and other auxiliaries is sufficient to heat the feed water for the entire plant. When the exhaust from these sources is equal to about 1/6 the entire quantity of steam generated by the boilers, there will

be nothing gained by placing a heater in the main exhaust pipe leading to the condenser; but if the exhaust from the auxiliaries is less than this amount, the feed water may first be passed through a heater supplied with steam at condenser pressure, and then through a second heater taking the pump exhaust at atmospheric pressure, which will raise the water to a temperature of 205 to 210 deg.

In case a vacuum heater is used, the simplest method of drainage is to drip it to the condenser, as in Fig. 6, when the latter is below the heater. When the condenser is on a higher level, a return trap with a high pressure connection must be employed to lift the condensation into the condenser or to discharge it into the hot well or sewer against atmospheric pressure. Such an arrangement is shown in Fig. 7.

Lifting Drainage to Sewer Level

Boiler rooms of many office buildings are below the level of the city sewers and all drainage must therefore be raised in order to be disposed of. The pneumatic ejector, shown in Fig. 8, is well adapted to this purpose. This consists of a chamber with inlet and outlet openings provided with checks as indicated. A pair of bells, or buckets, attached to a common rod automatically controls the compressed air and exhaust. When the water level in the chamber reaches a given point, the rising of the buckets admits compressed air, which forces out the contents through the discharge outlet, and the falling of the buckets with the water level closes the pressure pipe and opens the exhaust. The action of this device is automatic and discharges a given amount of water each time.

Boiler Setting Arches

Classes, and Their Construction. By Chas. N. Morgan

In every brick boiler setting it is necessary to use some arch construction. As this is more troublesome to install and maintain than the rest of the lining, it is well to give it a little extra consideration. The subject is one that presents an opportunity for a wide range of technical detail. It would be impossible to make an expert furnace builder out of oneself by the study of any work on the subject however elaborate. It is perfectly possible, however, that the brief discussion of a few of the main points may prove interesting and perhaps helpful to men who have work of this kind to do.

There are 3 principal classes of arches if we divide them according to their positions in the setting: inner arches, boiler door arches and back combustion chamber arches. Inner arches are those built within the combustion space over or near the fuel bed; they may be used with any type of boiler. Boiler door arches are the small arches at the firing openings in the front; they are used with all hand fired boilers and some types of stokers. Back combustion chamber arches form a roof for the space between the rear wall and the back of the boiler; they are used only with horizontal tubular boilers and some dry back Scotch boilers.

Inner Arches

The general object of an inner arch in a boiler setting is to help produce efficient combustion of the fuel. This primary purpose is served in a variety of ways. There are coking arches which hold the distilled gases until they can be brought in contact with incandescent fuel. There are deflecting arches which lead the gases in such directions as will insure their complete combustion. There are ignition arches which provide an incandescent roof whose radiated and reflected heat helps to ignite green fuel, distill its gases, or burn the gases already liberated. It is probable that in practice an arch designed for any one of these duties performs the functions of the others to a greater or less extent. It might, therefore, be difficult to fix exactly the class into which any given example should be placed.

This fact does not influence the general principles of arch design; these hold for all inner arches irrespective of their purpose. As far as the length is concerned, this is determined by the desired rate of combustion and the character of the fuel. If a fuel is easily ignited, the less need be the length of an ignition arch. It is also true, especially with hand firing, that the height above the grates should be greater for fuels of high volatile content. This is a matter, however, which really belongs to the larger question of combustion.

The ideal proportion between the rise and span of an arch is between 1 to 6 and 1 to 8. The flatter the arch, the greater the side thrust. Fire brick is not adapted to standing heavy pressures, particularly when hot, so this side thrust should be kept as low as possible. It may, therefore, be taken as a rough general rule that a fire brick arch should be given all the rise for which there is room. In the case of spans of 4 or 5 ft., this is not so essential; they may be made very flat and still give good results.

In practice, the arch is usually made 9 in. thick, undoubtedly on account of the fact that standard fire brick shapes are 9 in. long. This thickness is more than is actually required for small arches and not enough for very large ones. For the average arch, having a span of from 6 to 9 ft., it is a good thickness. With those of even wider spans, 9 in. is sufficient if the arch has a generous rise. For arches 10 ft. or more in span which do not rise at least 2 in. to the foot, blocks may be used which give a greater thickness than 9 in. These provide a larger bearing surface to take care of the excessive side thrust; as this is greatest at the spring line, it is not good policy to reduce the thickness of the arch at the sides. In furnaces where very high temperatures make the life of any arch short, the central part is sometimes thickened so as to prolong its usefulness. A use of specially thin blocks would seem to be warranted, then, only in the cases of wide and flat spans or destructive furnace temperatures.

In laying up a fire brick arch, ground fire clay mortar is used. This is mixed to the consistency of thick cream. It should be applied very sparingly to the upper half of the bearing surfaces of the arch blocks, then each block should be tapped tightly against its neighbor, which will result in a joint with a small opening toward the fire but tight on top. While the opening in the joint should not be big enough to admit a trowel blade, it will be sufficient to reduce the strain on the arch when the fire surface begins to expand.

Blocks should be used which exactly conform to the required radius. The right way to lay them is one course at a time and not in rings. One ring can be laid first as a gage of the number of courses needed. In doing this, it is advisable to move the skewbacks in or out a little so the ring will be just filled with whole blocks, which will overcome the necessity of splitting one course.

The skewbacks being thus properly spaced apart, the laying of courses will proceed from each side toward the center of the span. At the last, there should remain one whole course from front to back, to be laid. This is the key course, and it must fit snugly into the space left for it. If splitting of blocks has been necessary, it should have been done in some intermediate course so that the bearing surfaces of the key course and those adjacent to it may be smooth and true. It may take a little driving to get the key course in place, but too much force must be avoided on account of the likelihood of injury to the blocks. If the arch is properly gaged in the beginning by laying up one ring, no difficulty should be experienced during the rest of the construction.

As to the probable length of service to be expected from an arch built over a fire box, this is a question that cannot be given a definite answer. What one plant would consider excellent service, would be very poor under the working conditions of another. There are plants where it seems to be necessary to repair about every 6 months, and others where arches have lasted 5 or 6 yr. Probably the majority of plants using inner arches find it necessary to overhaul them at least once every 2 yr., and those who use high class stokers, artificial draft, and high rates of combustion, even oftener. It would be safe to say that under average conditions one might expect a minimum of 18 months service from inner arches provided they set a distance of 2 ft. or more above the fuel bed.

Boiler Door Arches

The boiler door arch, fire door arch, or door liner, is simpler in every way than the inner arch. Its purpose is to provide an opening in the front wall of the setting structurally capable of supporting the brickwork above and tough enough to withstand the hard usage due to firing. It should be of such design that it can be erected or repaired easily and not obstruct the firing operations while in service.

As to the shape of this arch, it of course must conform to the shape of the opening in the iron front. Its under surface should flare upward and to the sides so as to give room to spread fuel. Such a form is difficult to make with small brick because the fire clay joints have to be enlarged as the arch widens out. This becomes a point of weakness at once and makes frequent repairing necessary. An arch which is molded into just the proper shape is better, is easier to install, and has a greater chance to give long service.

Those portions of brickwork between and at the sides of the doors are called the jambs. On them the arches rest. They also may very well be molded into one piece blocks, and can then be obtained, together with the arch pieces, in complete sets to fit almost any sized opening.

The arch pieces should be thick enough to have ample strength. They must also have a top surface that will form a good base for the superimposed brick work around the smoke box or header. A level surface is preferable. The side pieces or jambs ought to be thick enough to give them solidity and prevent their being broken by the hard knocks they receive from the fire tools. Their depth would be the same as the dead plate, but the arch might overhang them somewhat if necessary to protect the first row of rivets in a horizontal boiler.

The life of an old-fashioned cast-iron boiler door arch under modern conditions is usually so short that brick is now used almost exclusively. The arch that is built up of small bricks will give a service depending altogether on the skill of its builder in overcoming its weak features. An arch made of specially molded large blocks should last 2 yr. at least and from 3 to 4 in the average case.

Back Arches

Another important arch is the one used to cover the rear combustion chamber of horizontal tubular boilers. The primary requirement in the design of such an arch is that it shall be gas tight. As a supplementary requirement of some importance, it must be flat across the boiler head so as to expose as little of the head as possible. There is an added advantage if it is flat from front to rear, in that there is more head room in the chamber and expanding tools can be used on the upper tubes without removing the arch. If, also, it can be taken out and replaced to make some unusual repair, and is made of refractory material, the back arch comes pretty near doing and being all that can reasonably be expected.

The one requisite, tightness, gives rise to most of the difficulty with this arch. The boiler has a slight longitudinal movement due to expansion and contraction, and the arch must be built so as to take care of this. It should be supported independently of the boiler. If this necessitates iron bars of any kind, they must be protected, for the temperatures in modern combustion chambers are very high. The space between the arch and the boiler head, usually not exceeding an inch, is kept packed with a cushion of asbestos or other material, thus forming an elastic joint between the movable boiler and the solid stationary arch.

If properly designed, the back arch should last an indefinite time; 15 or 20 yr. ought to be the minimum service it would give. Anyone who is satisfied with less is simply putting up with useless annoyance and expense. It is merely a question of getting an arch that answers all the requirements and there are several such on the market, all easily obtainable.

Characteristic Curves of Centrifugal Pumps*

Relation of Speed, Discharge, Discharge Head Horsepower Input and Output Readily Plotted on One Diagram. By F. W. Greve, Jr.

CHARACTERISTIC curves, illustrating the performance of centrifugal pumps, provide a clear and precise method of comparing the relative values of such pumps.

Characteristic curves may deal with either the design or the performance of a machine, limited only in that the curves must be characteristic of that type and follow the same general equation for any one type of machine, irrespective of size or make.

It is not the purpose of this paper to cover questions of design or actual results that have been obtained, but rather to illustrate a characteristic method of diagramming the experimental data pertaining to centrifugal pumps. The accompanying diagrams were developed from data, chosen at random from a number of tests, to illustrate average conditions. The curves deal with the head, speed, capacity, horsepower input and output, and efficiency of a 4-in. centrifugal pump. The horsepower output of the motor driving the pump is labeled b.hp. on

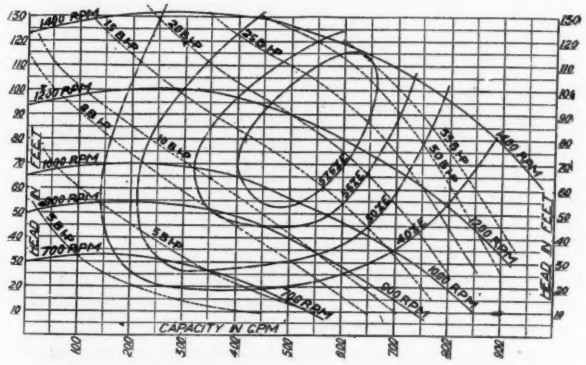


FIG. 1. CAPACITY-HEAD; ISO-EFFICIENCY-BRAKE HORSEPOWER CURVES, CONSTANT SPEED

the diagrams and was assumed equal to the horsepower input of the pump, no allowance being made for belt slippage.

Three series of curves have been plotted in Fig. 1. At present, we shall consider only the set showing the relation between head in feet and capacity in gallons per minute, the speed remaining constant for any one curve. As one might expect, the head decreases with increase of capacity (except with very small discharges), but the curves show that the maximum head does not occur at the minimum discharge, but at a point equal to about ⅓ of the maximum. Had these curves been continued, they would have dropped on a line approaching the vertical. From the fact that the curves are parallel or concentric, the relations of head and capacity can be easily established by simply sketching in a new curve for the desired speed, the curves established from the test data acting as guides.

*From a paper read before the Western Society of Engineers.

Figure 2 illustrates the changes in efficiency for various values of capacity when computed for a constant speed. Up to a certain limit, variable for each size or make of pump, the maximum efficiency and capacity are found to increase with an increase of speed. It may be noted that the point of maximum efficiency moves to the right or to a point of greater capacity, as the speed is increased.

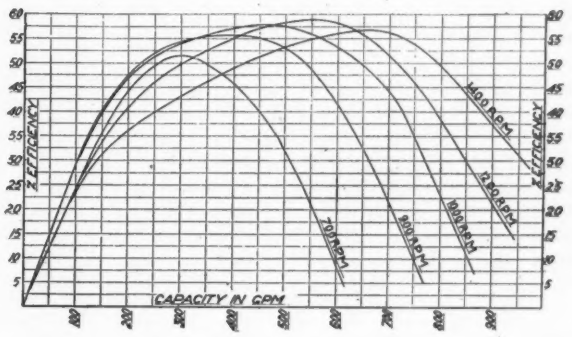


FIG. 2. CAPACITY-EFFICIENCY CURVES, CONSTANT SPEED

For small discharges, the efficiency is practically the same at any speed. In general, each one of these curves resembles a semi-ellipse with the line of abscissae, or the capacity-line, as the minor axis. On this diagram, a maximum efficiency of 58 per cent is obtained at a speed of 1200 r.p.m. and not at the highest speed.

The amount of horsepower supplied to a pump to give a definite discharge at a constant speed, is shown

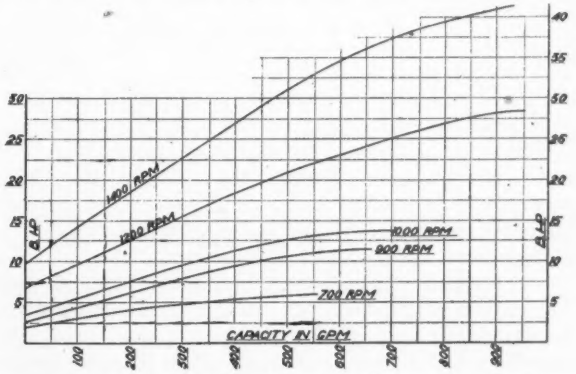


FIG. 3. CAPACITY-BRAKE HORSEPOWER CURVES, CONSTANT SPEED

in Fig. 3. As one might surmise, the horsepower input increases with the discharge for a given speed until the point of maximum capacity has been reached, when the curve becomes horizontal.

The curves in Fig. 4 have been plotted between brake horsepower and revolutions per minute, the capacity remaining constant for any one test. Naturally, the

input increases with the speed. These curves have been developed with the aid of Fig. 3. On the latter diagram, the brake horsepower has been read to give a constant discharge for the several speeds as plotted.

Curves determining the range in head for various speeds (the discharge remaining constant), are shown on Fig. 5, which was developed from Fig. 1 in much the same manner as Fig. 4 was obtained from Fig. 3. The equations of the curves follow closely those of straight lines, and indeed for large quantities may be assumed as such. This diagram and the one preceding it are not of great importance by themselves, but are valuable in determining the curves in Fig. 1.

Referring to Fig. 1, the series of curves drawn from the upper-left to the lower-right end of the sheet show the horsepower required to discharge any quantity of water against any head and at any speed within the limits of the pump. The method of determining these curves is illustrated by the following: In Fig. 4 let us locate the point of intersection of the lines of 700 r.p.m. and 5 b.hp. The capacity by interpolation will be found to be 340 gal. per min. At the intersection of the lines of 900 r.p.m. and 5 b.hp. the capacity closely approx-

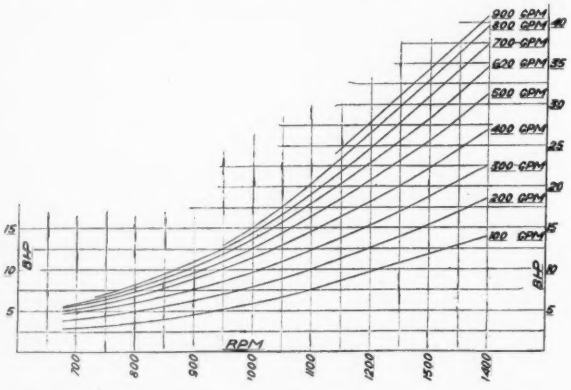


FIG. 4. SPEED-BRAKE HORSEPOWER CURVES, CONSTANT CAPACITY

imates 145 gal. per min. Repeat to secure several values of discharge and speed for the given horsepower. In Fig. 4, the 3 lines of capacity, speed and discharge may be found to average at one point and then no interpolation is necessary. It may be well to remember that interpolation may be made of either the speed or the capacity, the horsepower alone remaining fixed. Transpose to Fig. 1 the values of discharge and speed for the given horsepower. Here again interpolation may be necessary. Connect the several points of equal horsepower in Fig. 1, and the result is a curve showing the power required under various conditions of speed, capacity and head. In the same manner, curves of any power within the requirements of the pump may be drawn. These curves are nearly parallel, or concentric, when the range in horsepower is small. This fact is of great importance, for when the power is required for which no curves have been drawn, a new curve may be sketched in with reasonable accuracy.

In the general direction from the upper-right towards the lower-left side of the diagram, are shown a series of curves representing the efficiencies. In a manner similar to that employed in obtaining Figs. 4 and 5, a series of curves could be plotted between efficiency and speed for any constant capacity. This is not necessary, because all the data needed are available on Figs. 1 and 2. In Fig. 2 the line of 40 per cent efficiency will be found to cross the line of 1000 r.p.m. at the points of 150 and 700 gal. per min. Transpose these points of intersection of the lines of speed and capacity to Fig. 1, making use of all the speed curves drawn. Connecting the points of equal efficiency results in an Iso-Efficiency curve, or, in other words, a curve which shows the relations of head, speed, capacity, and horsepower required to give a definite efficiency. When by this method an insufficient number of points have been plotted, or it is desired to check the results obtained, recourse may be had to Fig. 1. For instance, assume any point on one of the horsepower curves. The head and discharge can be read immediately, and by the aid of these 2 quantities the horsepower output of the pump is readily obtained. This pump horsepower divided by the horsepower input at the same point will give the efficiency at this point. Just as in drawing contour maps, it is possible to plot any number of these points. For example, a head of 61 ft. with a corresponding discharge of 559 gal. per min.

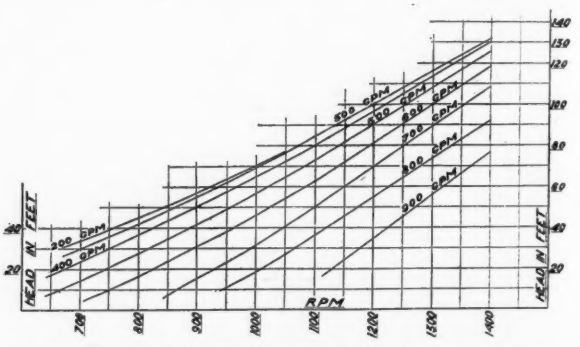


FIG. 5. HEAD-SPEED CURVES, CONSTANT CAPACITY

results in 8.6 hp. of work done by the pump. The horsepower input is 15 and the efficiency is found equal to 57.5 per cent. With a head of 82 ft. and a capacity of 416 gal. per min., the horsepower is 8.6, the horsepower input is 15, again resulting in an efficiency of 57.5 per cent.

The efficiency curves are similar to the ellipse. The major and minor axes of each curve intersect in a common point, or origin, about which the curves themselves are concentric. This point of intersection is also the point of maximum efficiency. Similar to the discussion of the brake horsepower curves, the fact that these Iso-Efficiency curves are concentric is very important. Efficiency curves which have not already been drawn can be sketched in with considerable ease and accuracy.

The advantages of representing the performance of a pump in the manner explained are several in number and are of interest to both the engineer and the manufacturer. The most valuable fact brought out in the preceding explanation is that in any series of curves in Fig. 1 the curves are parallel or nearly so. Figures 2, 3, 4 and 5 may be considered as supplementary to Fig. 1. Any question referring to the relations of speed, dis-

charge, head pumped against, horsepower input and output are quickly answered by reference to Fig. 1. In short, this diagram represents a map upon which the characteristics of the pump are indicated. It is the only one that is necessary to keep on file, thus reducing the amount of data to keep for reference. At the conclusion of a test, it is sufficient in itself in indicating the results obtained.

When more than one diagram is used in representing test results there is danger of error when the eye is deflected from one diagram to another. Tables are often prepared in lieu of diagrams which also give rise to error due to necessary interpolation and to the comparison of results, summed up under several headings.

In conclusion, the characteristic curves explained illustrate the results of a test in concise form; reduce the liability of error to a minimum; require the least amount of data to be kept on file or forwarded to a prospective buyer; and provide an easy method of comparison of various pumps.

Cost Accounting in Engineering Department of a Modern Hotel

TENDENCY OF ARCHITECTS AND OWNERS TO NEGLECT POWER PLANT; PROPER DISTRIBUTION OF CHARGES RESULT IN ECONOMICAL OPERATION. BY NEWTON L. SCHLOSS

CONSIDERING the vast sums spent each year for mechanical and electrical equipments of modern hotels, it is surprising that so little attention has been given to the development of more accurate systems of cost accounting of the engineering department in order to determine what proportion of the cost of operating this department should be properly charged to the various portions of the hotel.

It is one thing to say to the chief engineer to reduce expenses and another thing to put it in force without seriously affecting the various departments of any business unless a system of cost accounting has been developed to such a high degree of efficiency that the engineer can, in co-operation with the management and the heads of each department, almost immediately determine what proportion of the general reduction each department can stand. Again, it frequently happens that there is a great waste in the use of steam, electricity, gas, water, etc., the elimination of which cannot be accomplished as long as the various systems are treated as chargeable to general overhead.

The writer has discussed this subject with a number of business men and found that after they have become convinced of the importance of a general change in the system of cost accounting, as I have suggested, they frequently ask the question: "How does it happen that engineers do not design the mechanical and electrical equipment to make it possible to put these suggestions into practice?"

There are several reasons why this has not been accomplished, the most important of which are:

1. The architect and owners will spend thousands of dollars to produce a beautiful structure and equip it with all the modern appliances for the comfort and service of their guests and then finding their appropriation is being reached or exceeded will deliberately proceed to cut the heart of the engineering equipment, apparently on the theory that any old thing will do that will keep moving.

2. The architect and owners will instruct their engineer to study carefully every detail of modern hotel requirements and prepare plans and specifications to insure safety, comfort, rapid service and the reduction of cost of operation to a minimum, and then generally following the advice of a mercenary contractor who knows nothing about the working of the front or back of the house, allow him to destroy the work of the engineer who may have spent months in studying ways and means to avoid the mistakes of others and produce a model of efficiency.

3. The owners and management do not seem to realize the importance of skilled labor in their engineering department and frequently make the allowance for this department so low that an efficient force is impossible.

4. The owners and management, instead of bringing the executive and operating heads and the chief engineer together months before the opening of a hotel for the purpose of studying ways and means of reducing the operation and cost accounting to a science, usually wait until the house opens and then complain of the lack of smoothness in the general conduct of the house.

In designing the power plant, the engineer should provide efficient means of handling the coal and ashes to reduce the labor to a minimum. Accurate devices should be installed for weighing the coal before it is fed into the boilers, and if space conditions permit, the coal should be weighed before it is dumped into the storage bins. In this way the coal delivered is accurately checked against the amount contracted for and the coal consumed checked against the amount delivered. Scales should also be provided for weighing the ashes as a check against the amount of coal consumed.

Instruments should be provided to determine whether the firemen are getting full value for the coal consumed. The high pressure piping should be designed so that independent steam flow meter readings could be obtained from the mains serving the electric light and power engine, house service, hot water heater, ice machine engines, pumps and auxiliaries, boiler feeding pumps and auxiliaries, flat work laundry, house laundry, kitchen and serving pantries, floor service pantry, barber shop, bar and wine steward's department, and the emergency high pressure lines connected into the heating system. The high and reduced pressure drips being clean, they are usually returned to the feed water heater or modern boilers. Condensation meters make it possible to measure this condensation accurately, and so that return can be credited to the plant. The water supply, whether from the city mains or from an artesian well, should be

Daily Log of Renewals and Repairs

Date _____

	Direct Heating Renewals, etc.	Direct Heating Repairs	Elec. Light Wiring Renewals, etc.	Elec. Light Wiring Repairs	Plumbing Renewals, etc.	Ventilation Renewals, etc.	Ventilation Repairs	Hot Blast Heating Renewals	Hot Blast Heating Repairs	Electric Signal Renewals, etc.	Electric Signal Repairs	Electric Power Renewals	Electric Power Repairs	Refrigerating Renewals	Refrigerating Repairs	Pneumatic Tube Renewals	Pneumatic Tube Repairs	Elevator Renewals	Elevator Repairs	Electric Motors Renewals	Electric Motors Repairs	Electric Heating Renewals	Electric Heating Repairs	Vacuum Cleaning Renewals	Vacuum Cleaning Repairs					
Steward's Storage																													
General Storage																													
Machine Shop																													
Electrician Shop																													
Paint Shop																													
Upholsterer Shop																													
Printing Shop																													
Carpenter Shop																													
Kitchen																													
Service Pantries																													
Wine Storage																													
Bar																													
Public Dining Rooms																													
Private Dining Rooms																													
Bed Rooms, Parlors																													
Private Baths, Toilets																													
Public Baths, Toilets																													
Corridor, Exits, Guests Floor																													
Sewing & Linen Rooms																													
Flat Work Laundry																													
Guests' Laundry																													
Servants' Quarters																													
Servants' Kitchen, Dining Room & Laundry																													
Barber Shop, Manicure, etc.																													
Turkish Baths																													
Shops																													
Entrance, Vestibules																													
Lobby, Offices Public Rooms																													
Billiard Room																													
Sample & Show Rooms																													
Passenger Elevator																													
Freight Elevator																													
Service Elevator																													
Predetermined Rates of Costs																													

Compiled By _____ Approved by _____

FIG. 2. DAILY LOG OF RENEWALS AND REPAIRS

Daily Log of Consumption Costs

Date _____

	Steam	Electric Light	Electric Power	Refrigeration for Cold Water	Refrigeration for Cold Storage	Refrigeration for Air Cooling	Mechanical Ventilation	Hot Blast Heating & Fresh Air Supply	Cold Water Supply	Hot Water Supply	Air Supply	Pneumatic Tubes	Vacuum Cleaning	Ice Making	Gas Supply	Passenger Elevators	Freight Elevators	Dumb Waiters	Electric Heaters	Fire Alarm System	Watchman's Clock System	Maid, Waiter or Valet System	Electric Signs, Carriage Call	Telautograph System					
Steward's Storage																													
General Storage																													
Machine Shop																													
Electrician Shop																													
Paint Shop																													
Upholsterer Shop																													
Printing Shop																													
Carpenter Shop																													
Kitchen																													
Service Pantries																													
Wine Storage																													
Bar																													
Public Dining Rooms																													
Private Dining Rooms																													
Bed Rooms, Baths, etc.																													
Corridors, Exit, Stairs																													
Sewing & Linen Rooms																													
Flat Work Laundry																													
Guests' Laundry																													
Servants' Quarters																													
Servants' Kitchen and Dining Rooms																													
Barber Shop, Manicure, etc.																													
Stores																													
Entrns's—Vestibules, Lobby, Offices																													
Public Rooms																													
House Telephones, Switchboard, Rooms																													
Turkish Baths																													
Billiard Room																													
Sample & Show Rooms																													
Predetermined Rates of Costs																													

Compiled By _____ Approved by _____

FIG. 1. DAILY LOG OF CONSUMPTION COSTS

metered. If from the city mains and there is more than one supply line, each line should be metered. It is customary in most modern hotels to have the water from the city mains pass through filters, and discharge in one or more storage tanks usually equipped with manifold headers from which independent cold water mains are drawn to serve an apparatus requiring cold water. Each of these independent lines should be equipped with a meter as a check against the total consumption registered on the meters on the mains entering the building. It is customary to arrange the water piping for the ice making and refrigerating machinery so that the waste water from the condensers is carried back in the system; this waste line should be metered and the amount registered, deducted from the total amount required for this department. The system of boiler feeding should be arranged with main and auxiliary feed lines with independent measuring devices for each line. The easiest and most satisfactory way to accomplish this is to install not only the boiler feed pumps but the feed water heaters in duplicate. By such an arrangement the chief engineer can (assuming the supply, exhaust and drip piping is properly designed and cross connected) run a test on a part of the mechanical and electrical equipment without affecting the operation of the balance of the plant.

The development of the 3-wire system by means of which we can obtain 120 v. for lighting and 240 v. for power from the same generator has made it possible to install motor-driven apparatus throughout the building, and since electrical indicating and recording devices for measuring the current consumption are now within the reach of all users of electricity, there is no excuse for any one in charge of a plant for not placing meters in general service and obtaining accurate records of light, heat and power consumed, not only in each operating department, public portions of the building, but for the room service, public and private baths, corridor and exits; provided, however, that the feeding systems for the various portions of the building have been designed for independent control.

The same applies to the direct and hot blast heating, fresh-air supply, mechanical ventilation, elevators, dumbwaiters, ice-making, refrigeration, pneumatic tubes, vacuum cleaning, hot and cold water systems, the low tension signaling systems, etc. There are no doubt a number of up-to-date engine and boiler rooms equipped with coal, water, steam, electricity and air total consumption devices, which have developed a system of daily log sheets showing a record of such total consumption, together with labor required to operate and maintain the boilers, engines, pumps, heaters, generators, switchboard, etc., and that with the cost of delivering and handling of coal, removal of ashes, cost of oil and waste and cost of city water being fixed by contract, the wage scale depending on the class of help required, the interest and depreciation charges established, the amount of steam, electricity, refrigeration, and air required for various purposes can be readily determined and the cost rate for item of consumption easily computed.

Printed forms showing various methods of combining the different items to determine the cost of production at the original source of supply appear from time to time in technical magazines read by engineers, and it would be difficult to suggest any one form that would fit any case, since general arrangement of the apparatus and operating conditions should determine the exact method of computation.

Accounting systems of all hotels no doubt differ as to the method of computing the various operating charges and it would be difficult to suggest a system to conform to the views of everyone, but for the purpose of this article, I would separate my costs about as shown by the sheets accompanying this article.

In most up-to-date plants it is customary for a chief engineer to have one or more clerks whose duty it is to obtain the charts and log sheets from boiler, engine, ice machine, elevator and fan rooms, shops, chief electrician, etc., and compute the consumption and maintenance charges. To this staff should be added a competent accountant from the general office force whose entire attention should be given to compiling the records and computing the segregated charges and in turn passing these charges on to the general office. One of the most important and most expensive items of operating expense, and often the bone of contention, is the cost of *maintaining* the mechanical and electrical equipments, due in a great measure to the practice of not properly charging the cost of renewals and repairs to the department for which such renewals and repairs are made. In fact, it is not infrequent to find the maintenance charges applied so as to throw the burden of the greater portion of the charges upon the house, and thus make the cost of operating the power plant itself show up to a better advantage.

My suggestion would be to create a department of maintenance under the general direction of the chief engineer. This department should include the chief electrician, plumber and machinist and their staffs and treat the department as if it were a jobbing shop. Furnish the head of each house department or authorized assistant with a properly detailed and numbered triplicate order book and make it an ironclad rule that the chief engineer or his duly authorized assistant should not permit renewals or repairs to be made until an order is properly prepared and signed. Upon receipt of such an order, it is time-stamped and turned over to the man in charge of the class of work required, by the order clerk, and the equipment requiring repairs or renewals inspected and a descriptive requisition for the material required is turned into the supply room and the cost of such material and the labor required properly to carry out the order is charged against the department issuing the order. If, upon completion of the work, certain materials are not required, the amount is shown on the return slip portion of the original requisition and original order is credited with the cost of the material returned. If the renewal or repairs is of such a character that it is necessary to purchase material from a supply house or to have work done by an outside firm, the same system would apply with equally good results, except that the original requisition should be turned over to the General Purchasing Department or offices, and after the bills presented have been approved by the chief engineer, they are charged against the Department of Maintenance and Repairs and they in turn charge the cost of labor and material involved to the department for which the work was executed.

The systems suggested may seem complicated and expensive, but once put in practice and the staff made to understand that they are part of the general accounting system of the hotel, and any departure from them means dismissal, they would become so easy and avoid the dissension usually caused by inability to fix the responsibility for mistake that the work of operating and maintaining the mechanical and electrical equipment of a hotel would be considered a pleasure and not a hardship. It would help the purchasing department to account for every dollar's worth of supplies ordered. It would enable the management to obtain accurate figures at the end of each day (if necessary) for comparison with previous costs and by means of these to prepare curves showing consumption, renewals and repairs and their cost for daily observation. It would bring the chief engineer in closer touch with the executive offices of the hotel, and he will become a valuable assistant to the management.

It is most important that the chief engineer be a high grade man, capable of doing things, and imparting his knowledge to his staff so that the temporary or permanent loss of the services of any man in any department will not cause the slightest reduction of efficiency in the operation and maintenance of the plant. If possible, set aside a certain amount of the profits of your hotel each year to be divided among the deserving members of the staff of the engineering department, and thus encourage the men who keep your building going 24 hr. a day in the knowledge that they are in reality partners in the project and their reward depends upon their efforts, and I am sure you will find that these men will not only strive to reduce the cost of operations and maintenance, but will materially aid in establishing a more accurate system of cost accounting which will soon determine whether, as far as the mechanical and electrical equipment is concerned, the project is a success or a failure.—The Hotel Monthly.

Boiler Repairs

SOFT PATCH. BY J. HOWARD COATES

A SOFT patch may be termed a temporary repair, in fact it should be nothing else; for, due to the method of its application, the expansion and contraction of its integral parts are of such variance, that leakage except under constant vigilance is bound to occur with its attendant result, corrosion.

To the uninitiated, a definition of the term soft patch will not come amiss, and even the initiated as well. A soft patch derives its name from the fact that a rubber gasket is employed to make a tight joint between itself and the defective plate. The edges of the patch are consequently neither scarfed nor calked; it is in the nature of a coverplate, blind flange or any packed flange joint.

Because of its construction a soft patch is not applicable to that part of a boiler which comes in direct contact with the products of combustion and consequently is not feasible except upon the external shell of internally fired boilers, and above the fire line in the steam space of horizontal tubular externally fired boilers. The method of application is the same in all cases. The circumstances naturally differ, depending upon the necessary size of the proposed patch and the place, condition, thickness, etc., of the defective plate.

Assume a hypothetical case in which a horizontal tubular boiler develops a defect, due to corrosion or cracks about a steam connection on shell so that the nozzle requires removal and plate patched, a soft patch being feasible.

First secure boiler plate of sufficient size and tensile strength. Bend it carefully so as to conform to the arch of the shell's circumference; in other words, secure a good fit.

The proper size and number of cap screws or through bolts and their pitch must next be calculated. This will require a slight study. Many people assume that the more bolts or rivets used in a patch or joint the stronger it must become, calmly overlooking the fact that for each added bolt or rivet in excess of the necessary calculated number the strength of plate diminishes. Also, cap screws are not to be used unless the thickness of plate is sufficient to secure a full thread and good holding. The defective part of plate is then cut out and the edges smoothed to insure close application of the patch.

When possible, the patch should be placed in the required position and the bolt holes drilled through itself and the plate to be patched to insure absolute fairness and obviate the use of a drift pin; upon the use and abuse of which a volume might be written.

The remainder of the operation consists of inserting gasket and bolts and screwing down tight, being sure to "follow up" the bolts or cap screws, as the case may be, in proportions as the boiler warms up.

For purposes of illustration, we will assume that in this case the defective plate cut out is 8 by 12 in., the thickness of metal 5/16 in., and tensile strength of plate 60,000 lb. The patch should be of same thickness and T. S. and large enough to employ a lap of 3 times the diameter of bolt or cap screw to be used. By using a ¾-in. bolt the lap would become 2¼ in., making the patch 12½ by 16½ in., the bolt or cap screw circle or line would be ½ of 2¼ in., or 1⅛ in., which, taken from full size of patch leaves 11⅜ in. by 15⅜ in., upon which we are to figure the pressure and the number and pitch of ¾-in. bolts necessary. Assuming a pressure of 100 lb. per sq. in., the ultimate patch pressure becomes $11\frac{3}{8} \times 15\frac{3}{8} \times 100$, or 17,489 lb.

The strength of a ¾-in. bolt, based upon 6000 lb. per sq. in. of cross section, is 1811 lb., then $17{,}489 \div 1811 = 10$ bolts necessary to secure the patch; these must be equally pitched.

Another problem now confronts us, that of the weakened condition of the shell due to drilling for the bolts. The efficiency of remaining plate and bolts must be figured, and if less than the efficiency of the longitudinal seam a decrease in pressure is necessary.

Supposing the bursting pressure of the shell is 750 lb., the efficiency of joint 75 per cent, then at a safety factor 5, we have $750 \times 0.75 \div 5 = 112.5$ lb. working pressure.

The patch longitudinal seam or joint has an efficiency of 60 per cent, we then have $750 \times 0.60 \div 5 = 90$ lb., or the safe allowable pressure.

Happily, this method of repair is in most cases temporary and the dimensions are and should be small.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

The Interpole Machine

METHOD OF CORRECTING DISTORTION OF MAGNETIC FLUX; IMPROVING COMMUTATION AND AVOIDING SPARKING; ADJUSTING INTERPOLE SHUNTS. BY GORDON FOX

THE interpole, commutating pole or regulating pole, variously termed, is now finding extensive use upon direct-current machines, both motors and generators. Since the principal purpose of the interpole is to improve commutation, it is most generally used for service in which sparking was formerly most prevalent, such as railway and other motors subject to wide load fluctuations. Variable speed motors are almost exclusively so designed; 500-volt motors are generally equipped with them and they are used for 1200-volt motors, which are out of the question without them. High speed and high voltage generators and machines of the turbine type are now standard with interpoles. Since the interpole decreases the tendency to sparking and since sparking is a feature limiting the rating of a machine it is often possible to increase the ratings of standard frames by using interpoles, as this is done, heating and mechanical limitations are the only factors deciding the machine rating. With this variety of purposes and applications, the interpole finds a wide field of usefulness.

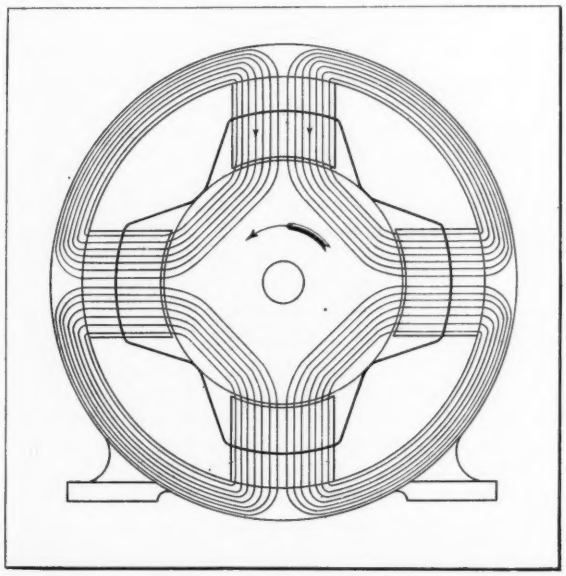


FIG. 1. UNIFORM MAGNETIC FIELD; NO DISTORTION

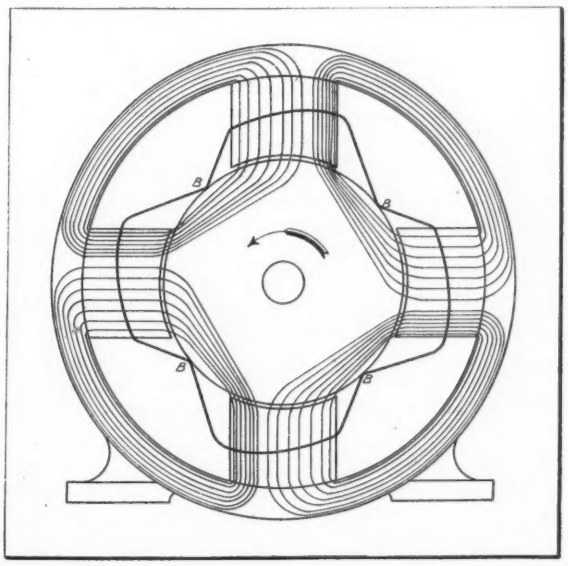


FIG. 2. DISTORTION OF FIELD CAUSED BY LOAD

The interpole improves commutation by opposing the forces causing sparking, which generally are due to armature reaction and inductance. Let us first consider armature reaction. Figure 1 shows how the magnetic flux flowing from a north pole through the armature is distributed in an ordinary 4-pole motor running without load. The heavy line illustrates the relative magnetic intensities under the poles and between them and it will be here seen that at a point midway between poles there is no magnetic flux, consequently no voltage is generated in coils passing through that zone. Thus, the neutral point or proper brush position is midway between poles (neglecting the throw of the leads from armature to commutator). Figure 2 shows how this distribution is changed when a load is thrown upon the motor. The current flowing in the armature coils has a magnetizing effect which tends to oppose or decrease the magnetism at one side of each main field pole and acts with or increases the magnetism at the other side, which results in the field and its relative intensities being distorted and shifted, as shown in the figure by the heavy line. It will be seen that coils passing through the zone midway between poles will cut some flux and will, therefore, have generated in them a low voltage. Since the coils under the brushes are momentarily short-

circuited by the brushes spanning 2 or more commutator bars, it is necessary that there be little or no voltage generated in them to avoid a local short circuit current which would result in sparking. The neutral point for this load is now at B, some distance from its no-load position. With each load there is a proper brush position which, on overloads, may amount to considerable shifting. Since on ordinary machines it is not feasible to shift the brushes with each change of load, they are usually set at an intermediate or compromise position between no load and full load neutrals. At this position the tendency to spark at no load, full load and overload is then a minimum.

Next, consider the case of an adjustable speed motor. In these machines the speed is increased by weakening the strength of the main field, and while with a given load the armature magnetizing effect is the same as before, it is now much stronger in relation to the weakened field. In other words, the ratio of armature magnetizing effect to field magnetizing effect is greater, as the field is weakened to raise the speed, and the higher the relative armature magnetizing effect the greater is the armature reaction or shifting tendency. The distribution of the flux and relative intensities is then similar to those shown in Fig. 2, but the distortion is more marked; hence, if an ordinary shunt-wound motor has its speed raised by weakening the field, it soon commences to spark.

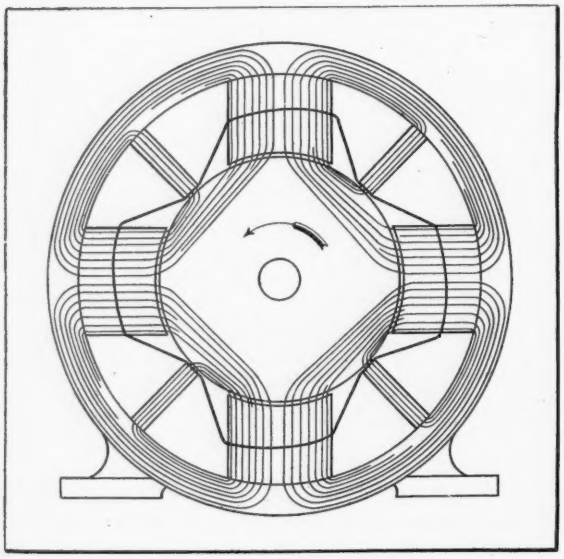


FIG. 3. DISTORTION CORRECTED BY USE OF INTERPOLE

If interpoles be inserted and properly magnetized, they can be caused to oppose the shifting tendency of the main field magnetism. It was seen that under load there is a resultant magnetic flux at the mid-positions between main poles. If the interpoles are inserted midway between the main poles, and so magnetized that they have an opposing tendency equal to this resultant magnetism, then it will be possible to neutralize and convert this zone into a neutral one. This is what the interpole accomplishes, and the distribution of flux for such a motor operating under load is shown in Fig. 3.

Since the armature reaction or shifting tendency is proportional to the armature current, the strength of the interpole should vary likewise, which is accomplished by connecting the interpole winding in series with the armature and working the iron of the interpole at a point below saturation, where the magnetism varies approximately as the magnetizing current. With heavy loads, the interpole becomes saturated, but under such loads the armature iron and main pole tips are also saturated and the shifting tendency is therefore moderated.

In each armature coil of a direct-current motor the current is continually reversing. Each commutator bar is first under one brush and then under the other, so that the current is going into or out of that bar alternately, and a change of current in the coil causes an inductive kick such as occurs in a spark coil. When an armature coil is under the brushes, at that instant the current in that particular coil drops to zero from one direction and changes to the other direction. The change in current intensity and direction of blow causes a self-induced voltage in the short-circuited coil under the brush which opposes the change and tends to maintain the current in the direction in which it was previously flowing. This energy stored through inductance is dissipated in a discharge through the short-circuited coil and brushes and causes sparking.

This effect is greatest in high-voltage armatures having a large number of turns in each coil with consequent large inductance. It must be borne in mind that the current in the active armature coils flows in a direction opposed by the generated electromotive force (in a motor) and in order to counteract the self-induced voltage under the short-circuited coil the voltage in that coil should be caused to drop to zero and be built up in the new polarity to help the change in current direction before the coil under the brushes is short-circuited. The south interpole shown, causes a magnetic field in the commutating zone which generates in the short-circuited coil a voltage in the same direction as the newly entering current and in opposition to the self-induced voltage. The interpole should therefore be strong enough, not only to counteract armature reaction, but also to create a slight field in the commutating zone to aid in the reversal of the current.

It was seen that a fixed relation of polarity must exist between interpole and main pole windings to obtain correct action. Interpoles of a motor should be of the same polarity as the next preceding main pole in a direction against the rotation, while those of a generator should be of the same polarity as the next pole following in a direction with the rotation. If the armature leads of a motor be interchanged while the field leads are undisturbed, the rotation is reversed; but if an interpole winding is present, its connections must also be reversed. If the armature leads of a generator be interchanged, the machine will not build up unless its rotation be also reversed, thus necessitating reversal of the interpole winding. Reversal of armature leads always means reversal of interpole leads, so that one armature terminal and one interpole terminal may be permanently connected and the armature-interpole circuit considered as a whole.

It was shown that the interpoles must have a certain proportionate magnetic strength in relation to the armature magnetizing effect. It is a difficult matter to predetermine exactly the proper interpole winding, therefore machines are usually designed having interpoles stronger than necessary; then, when they reach the test floor, the interpole winding is shunted by German silver wire or ribbon to any value desired, this being accomplished by the following procedure:

The machine is operated as a motor, first in one direction and then in the other, by reversing the armature-interpole circuit. The brushes are shifted until the speed in both directions is practically identical. Then a load is thrown on the motor, and if the speed drops greatly under load, if violent sparking occurs or a loud humming sound is heard, the interpole is connected in the wrong direction; otherwise it is correct. A full load is thrown on the motor and the speed taken. If the speed is higher than the no-load speed, the interpole is too strong; while, if the full-load speed is less than no-load speed by more than 2 or 3 per cent, the interpole is too weak. If, as is usually the case with new machines at the factory, the interpole is too strong, the motor will likely start to race or hunt. A German silver shunt is then connected across the interpole and the speed regulation again tried. This process is repeated with various shunt values until the motor operates at the same speed at no load and full load, or perhaps slightly slower at full load. It is then well to check neutral positions by the "exploring" method later described for adjusting generators. If the motor be of the adjustable speed type the German silver shunt should be determined with the motor operating at maximum speed, since under this condition it is most delicate and accurate.

If it is difficult to find the proper value of the shunt quickly, the interpole may be separately excited through a rheostat and the proper interpole current value determined with full-load current in the armature. The resistance of the interpole may then be measured and the resistance of the shunt calculated, taking into account the proper current capacity in making the selection. In applying this method, care should be taken to break the interpole circuit when the main circuit is opened to stop the motor, as otherwise the voltage generated in the armature revolving under the excited interpoles will cause flashing at the brushes, which are 90 deg. out of position with respect to the interpoles as main poles.

Adjustment of generator interpole strength is carried along somewhat different lines. The generator is first run as a motor and the brush position for reversibility (equal speed in both directions of rotation) is determined the same as for a motor. It is then connected as a generator and caused to build up to full voltage and given full load. If the interpole is reversed, violent sparking will occur. The interpole being properly connected the position of the full load neutral is found by the use of a low reading voltmeter and exploring cords, which are made up from 2 pieces of No. 6 rubber covered wire taped side by side and connected to a short section of lamp cord, the bared ends of the No. 6 wire being bent so that they will span from one commutator bar to the next. Placing these terminals on the commutator at the brushes it is possible to locate the neutral, since at each side of the neutral the low-reading voltmeter will register a voltage between bars. On one side of the neutral this voltage will be in one direction, on the other side of the neutral it will be in the opposite direction. The German silver shunt across the interpole winding is so adjusted that the full load neutral and no load neutral coincide directly under the brushes. If the interpole is too strong the full load neutral will lie in a direction against the rotation; if it is too weak the neutral will shift in a direction with the rotation with increase in load just as occurs in an ordinary machine, but to a lesser extent.

It has been stated that a German silver resistance should be used to shunt the interpole winding. This may be modified by saying that if the machine is to be subject to widely fluctuating loads, the German silver shunt should be reactively wound upon an iron core worked below saturation. If a noninductive German silver resistance shunts the inductive interpole winding, when sudden load changes occur the self inductance of the interpole causes it to respond more slowly to changes in load current than the German silver shunt, and the proper ratio of interpole to German silver shunt current is not maintained at these instants when the interpole should have correct strength to prevent sparking.

Experience in the Operation of Electrical Machinery

By E. C. Parham

NEGLECTING the no-load or magnetizing current of a constant-potential transformer, the primary current is proportional to the secondary current, as is shown by the following succession of actions. Increased secondary current increases the opposing secondary flux which neutralizes more of the primary flux and thus decreases the counter e.m.f. of the primary coil, thereby permitting the primary current to increase until the core flux is restored to approximately its no-load value. In other words, the core flux is maintained at a practically constant value because the primary current automatically responds to changes in the secondary current.

With current transformers, the conditions are different. The value of the primary current depends upon an external load over which the current transformer has no control. Assume that the current-transformer primary current, which is the current output of some generator, is kept constant at full-load value. A suitably calibrated instrument, placed in the secondary circuit, will indicate the value of the primary current, although the secondary current to which the indication is due is but a small known part of the primary current. Owing to the fact that there are many more secondary than primary turns, the ampere-turns of the 2 windings are approximately equal and the opposing flux caused by the secondary is able to neutralize the flux of the primary to such an extent as to keep the core flux density below the value that would generate objectionable heating.

Next assume the secondary to be short-circuited, another instrument placed in series with the existing one, and the temporary short-circuit (used to avoid opening

the secondary) removed. The secondary resistance will now be greater than it was with but one instrument in circuit and consequently there will be a tendency for the secondary current to decrease. Any decrease in the secondary current, however, increases the core flux because less of the primary flux will be neutralized. The increased flux cutting the secondary turns increases the secondary e.m.f. and thereby restores the secondary current almost to its former value. Up to the instrument capacity of the transformer, additional instruments further increase the core flux and, hence, the secondary e.m.f. The secondary current is thus maintained so close to the correct value that the error may be neglected except in precision work.

The greater the number of instruments used in series, the greater will be this error, the hotter the transformer will become on account of the greater flux density at which the iron is worked, and greater will be the voltage to which the secondary insulation is subjected.

If the secondary be opened, its flux-neutralizing capacity ceases entirely and the core flux density, due to the unopposed primary flux, becomes abnormal and the heat resulting from rapidly reversing the flux at this density soon raises the iron to a temperature dangerous to the coil insulation. Furthermore, this greatly increased flux cutting the secondary turns induces therein an electromotive force far exceeding that which obtains under normal conditions. These 2 effects tend to break down the secondary insulation.

It is necessary to issue a warning against operating a current transformer with its secondary circuit open.

Heating and Sparking of Repulsion-Induction Motors

Repulsion-induction motors operating under normal conditions are characteristically free from sparking. Even when irregularities exist, the sparking may be so slight as to mislead one who is accustomed to operating only the other kinds of commutator motors.

An operator noticed that one of his press motors was overheating and was sparking; similar motors operating similar presses were giving no trouble. In an effort to determine the cause of the difficulty, the operator interchanged 2 of the motors—a good one and the one under consideration. The trouble remained with the same motor. He then cut an ammeter successively into the stator circuit of each of 3 duplicate press motors, which had evidenced no trouble, and found that the current required under regular working conditions was 2½ amp. The faulty motor was operating under exactly the same conditions of load as were the 3 good motors just mentioned, but the ammeter when placed in its circuit indicated 5 amp. Since the full-load current rating of the motors was 3.8 amp., the motor under examination was carrying a current overload of nearly 30 per cent.

Reversing the compensating field connections only made matters worse. By shifting the brushes a little at a time, he found a position where the current was of the same value as for the good motors. He was now reasonably sure that the motor would not overheat, but as the sparking had not been lessened he called in a repair man whose examination disclosed an open-circuited armature lead. This condition was indicated by the burning out of the mica between diametrically opposite pairs of commutator bars. The repair of this lead resulted in perfectly normal operation.

Excessive Pump Output

The amount of water delivered by a centrifugal pump depends, among other things, upon the speed of the impeller. The delivery and speed variations, however, are not directly proportional to each other for, by reason of the characteristics of this type of pump, a certain per cent increase in speed produces a greater per cent increase in the amount of the water delivered. If, therefore, on account of high or low line voltage, or on account of design irregularities, the speed of the motor of a motor-driven centrifugal pump falls below or rises above the permissible 5 or 6 per cent variation, the water delivery may be materially affected; and, in the case of increased speed, the motor may be seriously overloaded. All conditions will be covered in a specification stating the speed at which the pump shall deliver water at a certain rate without the motor temperature rise exceeding a certain number of degrees.

A certain operator complained that his pump motor was running "red-hot" on regular duty but was otherwise entirely satisfactory. Ammeters connected into the motor circuit showed the motor was heavily overloaded. Measurement of the water delivery rate showed it to be about twice that which had been specified. The pump maker was notified and his subsequent investigation revealed the fact that the wrong impeller had been supplied with the outfit. The pump manufacturer got out of his difficulty to advantage, however, because the operator was so much pleased with the water output that he had been obtaining that he readily agreed to pay the difference in price between the motor that had been furnished and one large enough for the work.—General Electric Review.

A man is never as big as his job until he can make his job as big as himself, for the job is not the man until he makes it so. A little man in a big job can never stretch himself to cover the job, but a big man can always bring his job to his own size, and Nature pays men not according to what they do but how they do it.

Your job will always give back to you just what you put into it. If you tackle it with a grouch it will give back a greater grouch. If you go after it as if nothing in this splendid spherical world was better worth doing, it will give back the thrill of genuine accomplishment, than which there is no greater gain in life.

Just doing a thing will never get you anywhere: you must learn to *like* doing it and then do it for the joy you find in it.

Tackled in this spirit the meanest job becomes a beautiful thing, beautiful both to the creator and to the intelligent beholder.

That man who lights a spark of pride in his eyes while showing the tools of his craft and the manner of it is living a larger life than a great many you and I may look up to as bigger men.

Bigness is mental in men, after all, and if only you and I were but bigger ourselves we would always see the truth of it in measuring men and their jobs.—Logging.

Choice of Equipment

DEVELOPMENT OF FORMULA WHICH MAKES COMPARISONS SIMPLE. BY HENRY B. JONES

OFTEN an engineer is called upon by the men in the office to recommend the type of equipment to be installed, in the event of additions to the plant. The question of "simple, compound, or turbine" often arises. Where exhaust steam is used for heating or similar purpose, or where floor space is very valuable, the question becomes, at times, complicated; however, there are many cases in which it is merely a question as to whether the more economical equipment will save enough to warrant the additional first cost. To do this, it must earn depreciation charges, interest, taxes and insurance on the additional investment required, and should pay, besides, the same profit that the rest of the plant returns to its owners.

The general principles involved in this matter are assumed to be known to the average engineer, and attention is here called only to the fact that the cost and evaporative quality of the fuel used are most important considerations. Second only to these, is the matter of load factor, for a compound engine, for instance, saves only while it is running, and unless it is kept operating, and hence saving, a large enough part of the time, the necessary saving will not be effected. The following formulas are developed to show at what annual load factor the required saving is attained, other conditions being given, and to show the various relations of the several factors entering into the calculation.

D = Difference in the cost of the 2 installations being considered.

e = Percentage of D which must be the minimum saving earned annually by the more economical installation to warrant the additional investment.

$\frac{De}{100}$ = Amount in dollars, of foregoing.

P = Pounds of water evaporated by one pound of fuel under service conditions.

S = Pounds of steam saved per indicated horsepower-hour by use of the more economical engine.

C = Cost of fuel in dollars per ton of 2000 lb.

c = Cost of fuel in cents per pound.

H = Number of indicated horsepower-hours output required to effect saving $\frac{De}{100}$.

W = kilowatt-hours required to save $\frac{De}{100}$ (measured at switchboard).

K = Capacity of unit in kilowatts.

L = Annual load factor required to effect saving of $\frac{De}{100}$.

E = Overall efficiency of unit.

Then, Fuel cost of one pound of steam $= \frac{c}{P}$.

and Fuel cost of S pounds of steam $= \frac{Sc}{P}$.

Hence, Saving in cents per indicated horsepower-hour developed $= \frac{Sc}{P}$.

$$\text{and } H = \frac{De}{100} \div \frac{Sc}{P} = \frac{DPe}{100Sc}.$$

$$\text{But, } c = \frac{C}{20}.$$

$$\text{Hence, } H = DPe \div \frac{100SC}{20}.$$

$$(1)\quad H = 0.2\,\frac{DPe}{SC}.$$

$$\text{Now } W = \frac{746\,H}{1000}\,E$$

$$\text{and } H = \frac{1000\,W}{746\,E}.$$

$$\text{Hence } \frac{1000\,W}{746\,E} = 0.2\,\frac{DPe}{SC}.$$

$$(2)\quad W = 0.1492\,\frac{DPeE}{SC}.$$

Since there are 8760 hr. in one year,

$$L = \frac{W}{8760\,K}.$$

$$(3)\quad L = 0.000{,}017{,}03\,\frac{DPEe}{SCK}.$$

In this form (3) the formula is for use in calculations concerning generating units. By inserting a factor F = Mechanical efficiency of engine, formula (1) becomes

$$(4)\quad H = 0.2\,\frac{DPFe}{SC},$$

and we have a formula adapted for use in the case of engines in other classes of service. (3) may readily be transposed to give values for any of its factors, the others being assumed. Where 2 factors are unknown, curves may be plotted showing the relation existing between those two.

There are a number of features to be considered in connection with these factors, which will be briefly touched upon. In general, 20 or 25 per cent should be a sufficient gross annual earning on the additional investment required to secure the more economical in-

stallation. The amount D is sometimes limited by the pocketbook of the investors, but only too often these men lose sight of the fact that the economic ideal is not "the smallest possible investment, but rather the largest possible return per dollar invested."

$$L = 0.000,017,03 \frac{DPEe}{3CK}$$

$D = \$400$ $\quad S = 4''$

$P = 6\#$ $\quad K = 35\ KV.A(KW.)$

$E = 0.7$ $\quad C = \$4$

$e = 20$

$$L = \frac{0.000,017,03 \times 400 \times 6 \times 0.7 \times 20}{4 \times 35 \times 4} = 0.102$$

$C = \$2$ $\quad L = 0.204$

$C = \$6$ $\quad L = 0.068$

SAMPLE CALCULATION TO DETERMINE WHICH ENGINE TO INSTALL

The evaporative performance of the fuel depends, of course, upon the fuel itself, and upon the steam generating equipment, and in lack of more definite data, it may be assumed from results obtained in installations similar to that proposed, where the same fuel is used. The saving in steam per indicated horsepower-hour may be taken from the guarantees of the builders of the equipment being considered, and usually would be the average of the differences in steam consumption at several different loads; for instance, 25, 50, 75, 100, and 125 per cent load. If, however, it is positively known that the unit will never run at less than half load, the figures at 25 per cent load should be ignored.

The term "annual load factor" is here used to represent the ratio of actual annual output to the greatest possible annual output with the unit carrying full load, 24 hr. a day, 365 days a year. The overall efficiency of the unit is the kilowatt-hour output as measured at the switchboard divided by the indicated horsepower input as measured by the indicator, reduced, of course, to like units. In the case of an engine driving other than electrical machinery, the efficiency is the ratio $\frac{\text{B.hp.}}{\text{I.hp.}}$.

This formula in its various forms will lend itself very conveniently to cases involving condensers, or even the question of scrapping present equipment for newer, and more economical types, by merely paying proper attention to the factors D and e.

The accompanying calculations are the exact figures in an example which recently came up. In this case the question was between simple and tandem compound single valve engines direct connected to a 35-kv.a. alternator.

Use of a Slide Rule

ITS APPLICATION TO ENGINEERING PROBLEMS; COMPARISON OF SLIDE RULE AND LOGARITHMIC CALCULATIONS

THEORY and general application of the slide rule having been covered in previous articles, it is desirable to take up some more advanced work and further applications of the slide rule to engineering calculations.

HEATING SURFACE OF TUBULAR BOILERS

LET IT be required to find the heating surface of a horizontal return tubular boiler 36 in. in diameter, 12 ft. long and containing 160 2-in. tubes.

As the heating surface of horizontal tubular boilers is the sum of the products of: ½ the circumference of the shell times its length; the circumference of a tube times its length times the number of tubes; and ⅔ the area of the back tube sheet minus the combined area of its tube ends, it will be necessary to break this problem up into parts.

One-half the circumference of the shell times its length is equal, in this case, to ½ times 3.1416 times 3 times 12, which may readily be obtained from the slide rule by setting 2 on B under 3.1416 on A; place runner over 3 on B; 1 on slide to runner; runner to 12 on B; and on A under runner find 56.7 sq. ft.

The circumference of a tube times its length times the number of tubes is equal to 2 times 3.1416 times 12 times 160, which product must, to reduce the result to square feet, be divided by 12. As, however, 12 divided by 12 is 1, we can readily drop that part of the work. We therefore set 1 on B under 3.1416 on A; runner to 2 on B; 1 to runner; runner to 160 on B, over which on A we find 1005 as the number of square feet of tube heating surface.

Two-thirds the area of the rear tube sheet minus the combined area of its tube ends is found by subtracting the product of (2 divided by 12) squared times 0.7854 times 160, from the product of ⅔ times 3 squared times 0.7854. The first part of this process may be obtained by setting 144 on B under 4, the square of 2, on A; runner to 0.7854 on B; 1 to runner; runner to 160 on B, over which on A find 3.48.

By inspection it is readily seen that ⅔ times 3 squared is equal to 6; therefore, to find the product of 6 times 0.7854 set 1 on B under 6 on A, and over 0.7854 on B find 4.71 sq. ft. We now have 56.54 plus 1005 plus 4.71 minus 3.48 or 1062.77 sq. ft. of heating surface.

ENGINE PROBLEMS

HAVING GIVEN the diameter of an engine cylinder in inches and the period of admission, it is required to find the number of cubic feet of steam in the cylinder at cutoff.

Let the cylinder diameter be 26 in. and the stroke 40 in., with cutoff at ⅝ stroke. Multiply the square of 26 by 0.7854 by ⅝ of 40, and divide by 1728 to reduce to cubic feet.

Set 1 on B under 26 on A; runner to 26 on B; 1 on B to runner; runner to 0.7854; right-hand index of B to runner; runner to 25, ⅝ of 40, on B; 1728 on B to runner and over right-hand index of B find 7.68 cu. ft. on A.

The indicated horsepower of a steam engine is equal to the quotient obtained by dividing the product of the mean effective pressure times the length of stroke in

feet times the area of the piston in square inches times the number of strokes (equal to 2 times the number of revolutions) by 33,000.

Having, therefore, a mean effective pressure of 38 lb. per sq. in., a cylinder diameter of 27 in., a stroke of 32 in., and a speed of 57 r.p.m., the indicated horsepower of an engine may be found by dividing the product of 38 times 27 squared times 0.7854 times 2 times 32 times 57 by (33,000 times 12). The 12, in this case, is introduced to express the stroke in feet instead of inches.

To solve this on the slide rule, set 1 on B under 38 on A; runner to 27 on B; 1 on B to runner; runner to 27 on B; 1 on B to runner; runner to 0.7854 on B; 1 on B to runner; runner to 2 on B; 1 on B to runner; runner to 32 on B; 1 on B to runner; runner to 57 on B; place 33,000 on B under runner; runner to 1 on B; 12 on B to runner; over 1 on B find 200 on A as the indicated horsepower.

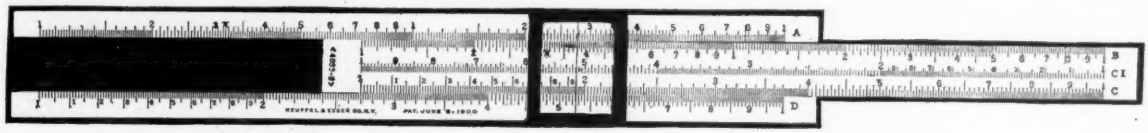


FIG. 1. RULE SET FOR 27 SQUARED, TIMES 38; ONE SETTING INSTEAD OF 2

In the solution of this problem, a double setting was made to obtain the square of 27. By placing the left-hand index on C over 27 on D, we find the square of 27 or 729 on A, thus eliminating an extra setting. The problem may then be carried on by placing the runner over 38 on B; 1 on B to runner and then in the order given.

Coal Consumption

Knowing the amount of coal consumed in tons per week of 56 hr., and the indicated horsepower, the amount of coal required per indicated horsepower-hour may readily be found by dividing the product of the number of tons, times 2000 to obtain number of pounds, by the indicated horsepower times the number of hours the given amount of horsepower is being developed.

Let the number of tons of coal used per week be 24 and the indicated horsepower 300, then the number of pounds of coal consumed per indicated horsepower-hour is equal to the product of 24 times 2000 divided by the product of 300 times 56 found on the slide rule by setting 1 on B over 24 on A; runner to 2000; shift 300 on B under runner; 1 on B to runner; over 56 on B find 2.68 on A.

Electrical Problems

Due to the average engineer being brought into such intimate contact with electricity and electrical machinery, a few problems on those subjects will be given.

From elementary electricity, we know that the resistance of a conductor is equal to a constant times the length of the conductor in feet divided by its cross-sectional area in circular mils. The constant referred to is the resistance in ohms per mil-foot of the substance of which the conductor is made and in the case of copper is 9.6.

To find the resistance per mile of copper wire 64 mils in diameter, set 1 on B under 9.6 on A; runner to 5280 (feet per mile) on B; 64 on B to runner; runner to 1; 64 on B to runner; over 1 on B find 12.3 ohms on A.

One electrical horsepower is equivalent to 746 w., and the horsepower expended in sending a current through a circuit is equal to the product of the current squared times the resistance of that part of the circuit in question. We, therefore, know that if a current of 15 amp. is forced through a resistance of 220 ohms, the energy expended is equal to the product of 15 squared times 220, divided by 746, found by setting 1 on B under 15 on A; runner to 15 on B; 1 to runner; runner to 220 on B; place 746 on B under runner and over the right-hand index of B find 66.3 hp. on A.

Power in a 3-phase alternating-current circuit is equal to $\sqrt{3}$ times the current flowing in each line times the voltage across any 2 lines.

Determine the electrical horsepower delivered by a circuit each line of which is carrying 100 amp. with a potential difference across the lines of 200 v.

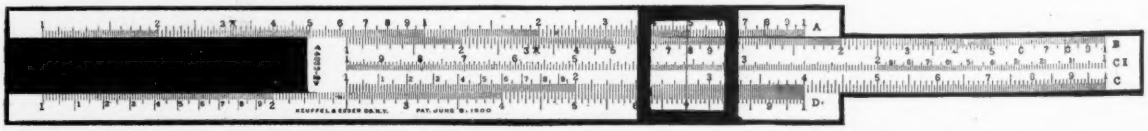


FIG. 2. AREA OF PISTON IS 491.3 SQ. IN.; DIAMETER FOUND BY SETTING 0.7854 ON B UNDER 491.3 ON A. OVER LEFT HAND INDEX ON B FIND 625, THE DIAMETER SQUARED ON A; UNDER 1 ON C FIND THE DIAMETER, 25 IN., ON D

Set runner over 3 on A under which on D find 1.73, the square root of 3. Place 1 on C over 1.73 on D; runner to 2 on C; 746 on C to runner; under right-hand index on C find 4.63 hp. on D.

Comparison of Slide Rule and Logarithmic Calculations

While the slide rule is accurate to within 4, and at most 5 significant figures, and can readily be used as a check on arithmetical work, a higher degree of accuracy may be obtained by the use of logarithms. The truth of this may be seen in the following, in which we have worked out a problem both with the slide rule and by logarithms and compared the results.

Determine the diameters of the cylinders of a cross-compound engine having given a piston speed of 650 ft. per min., mean effective pressures of 10.32 and 77.5, of the low and high-pressure cylinders respectively and an

indicated horsepower of 750 developed in each cylinder.

We know that indicated horsepower of an engine may be found by dividing the product of the mean effective pressure times the area of the piston times the

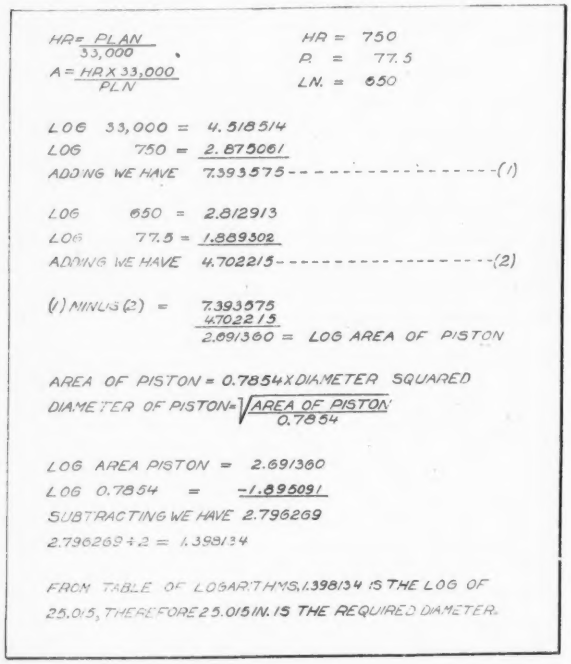

HR = PLAN / 33,000
A = HR X 33,000 / PLN
HR = 750
P = 77.5
LN. = 650
LOG 33,000 = 4.518514
LOG 750 = 2.875061
ADDING WE HAVE 7.393575 ----------(1)
LOG 650 = 2.812913
LOG 77.5 = 1.889302
ADDING WE HAVE 4.702215 ----------(2)
(1) MINUS (2) = 7.393575 / 4.702215 / 2.691360 = LOG AREA OF PISTON
AREA OF PISTON = 0.7854 X DIAMETER SQUARED
DIAMETER OF PISTON = √(AREA OF PISTON / 0.7854)
LOG AREA PISTON = 2.691360
LOG 0.7854 = -1.895091
SUBTRACTING WE HAVE 2.796269
2.796269 ÷ 2 = 1.398134
FROM TABLE OF LOGARITHMS, 1.398134 IS THE LOG OF 25.015, THEREFORE 25.015 IN. IS THE REQUIRED DIAMETER.

FIG. 3. HIGH-PRESSURE CYLINDER CALCULATIONS

speed of the piston by 33,000, and from which by transposition the area of the piston is equal to the product of the horsepower times 33,000 divided by the product of the mean effective pressure times the piston speed.

Taking up the high-pressure cylinder first, the area of its piston will in this case be found by setting 1 on B under 33,000 on A; runner to 750 on B; place 77.5

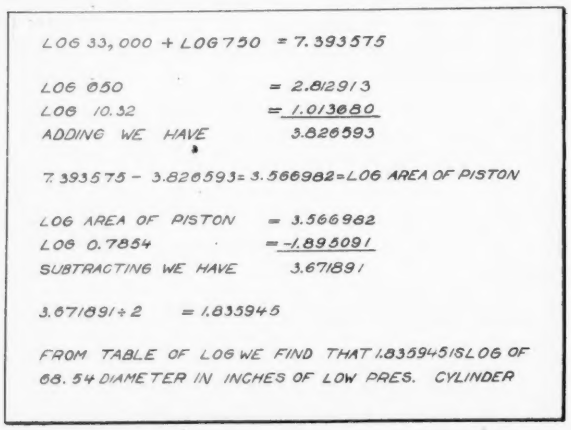

LOG 33,000 + LOG 750 = 7.393575
LOG 650 = 2.812913
LOG 10.32 = 1.013080
ADDING WE HAVE 3.826593
7.393575 - 3.826593 = 3.566982 = LOG AREA OF PISTON
LOG AREA OF PISTON = 3.566982
LOG 0.7854 = -1.895091
SUBTRACTING WE HAVE 3.671891
3.671891 ÷ 2 = 1.835945
FROM TABLE OF LOG WE FIND THAT 1.835945 IS LOG OF 68.54 DIAMETER IN INCHES OF LOW PRES. CYLINDER

FIG. 4. LOW-PRESSURE CYLINDER CALCULATIONS

on B under runner; 1 to runner; 650 on B to runner; over 1 on B find 491.3 on A. As the diameter of a circle is equal to the square root of the quotient obtained by dividing the area by 0.7854, we may set 0.7854 on B under 491.3 on A, and over the left-hand index of B find 625 the diameter squared; the square root of this is directly below on D or 25 in., as shown in Fig. 2.

In a like manner, the diameter of the low-pressure cylinder may be found.

Set 1 on B under 33,000 on A; runner to 750 on B; dividing, place 10.32 on B under runner; runner to 1; 650 on B to runner; runner to 1; place 0.7854 on B under runner; under right-hand index of B find 68.5 on D.

Figures 3 and 4 illustrate the logarithmic computations and by a comparison of these results with those obtained by the slide rule, we have the following:

	Slide Rule	Logarithms
High-pressure cylinder diameter	25 in.	25.015 in.
Low-pressure cylinder diameter	68.5 in.	68.54 in.

Cooling Tower and Cooling Ponds*

THEIR CONSTRUCTION, OPERATION AND PERFORMANCE. BY W. G. STEPHAN

COOLING or spray ponds occupy large areas and are applicable only to plants where ground space is cheap.

A spray pond consists of a large shallow reservoir of water, usually built of concrete and above which is placed a horizontal system of piping terminating in a number of specially designed nozzles which spray the hot water up into the atmosphere to be cooled. The pressure required at the nozzle varies from 5 to 10 lb. per sq. in., the higher pressures giving the better results. Pond areas required are approximately given by estimating 0.4 to 0.5 gal. of water cooled per minute per square foot of pond surface with a depth of water not exceeding 3 or 4 ft.

Cooling towers are of 2 general types, the forced draft and the natural draft. Both consist of a steel or wooden frame mounted over a basin of water built either of concrete or of steel and of a size dependent upon the quantity of storage water needed. In both types the water to be cooled is pumped into the tower, where a system of horizontal troughs about 22 ft. from the ground level distributes the hot water over a series of baffles or checker work intended to break up the water into small drops or films, so as to permit intimate contact with the current of cooling air coming up from the base of the tower.

In the forced draft type, the air circulation is caused by 1 or 2 power-driven fans located in the sides at the bottom of the tower. In the other type, the air circulation is due to the draft of a chimney on top of the tower proper. The advantage of the natural draft type is its low cost of operation due to the fact that no power is expended in maintaining the air circulation, while its disadvantages are that its air circulation is somewhat dependent upon barometric and atmospheric conditions and that it occupies a larger ground area than the forced draft type. Where space is no factor and ground area is not important, the natural draft tower finds its particular field. The average load factor for this type of tower is about 1½ gal. per min. per sq. ft. of ground space, this being about ⅓ the area of a spray pond.

*From a paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers.

The advantages of a forced draft tower are that its air circulation is independent entirely of atmospheric conditions and the small floor space necessary. The average load factor of a forced draft tower is about 6 to 7 gal. per min. per square foot of ground space, which is approximately 1/12 the area of a cooling pond and ¼ the area of a natural draft tower.

Both towers depend upon evaporation, convection, and radiation to reduce the temperature of the water. Evaporation is the most effective, convection is next in importance, while radiation is but a small factor. Consequently, cooling towers are arranged to evaporate as much water as possible. It is the aim of the designer to present as large and as thin a film of water to the air as possible, and to bring the largest possible volume of new air into intimate contact with it with the least power expenditure.

The absolute limit to which the cooling of water may be carried is the dew point. In the best commercial practice today with forced draft towers, it is possible to cool water to a temperature about 15 deg. F. above the temperature of the dew point, while with the natural draft tower a temperature 20 deg. F. above that of the dew point can be maintained. It is interesting to note that the drop in temperature can be made considerable but it seems to be more difficult to cool from 95 deg. F. to 85 deg. F. for example, than it is to cool from 125 deg. F. to 85 deg. F. with the same atmospheric conditions.

Performance of Cooling Towers

Perhaps the most reliable and accurate tests ever made on cooling towers were those conducted by the Wheeler Condenser & Engineering Co. of Carteret, N. J., the results of which are printed in the accompanying table:

Tests on a Forced Draft Cooling Tower
averages of 3-hour readings

Water				Air				
	Temperature Deg. F.			Temperature Deg. F.		Humidity Per cent.		Quantity measured by anemometer
Gal. per min.	In	Out	B. t. u. per min.	In	Out	In	Out	Cu. ft. per min.
651	105	84.7	110 000	71	90	40	100	53 900
638	107.8	87.5	108 000	72	93	60	100	50 100
638	112	88.5	124 500	64	96	60	100	51 400
643	108.5	87	115 000	69	92	48	100	52 200
640	109.9	90.5	103 400	83	95	48	100	50 600
*632	116	98	94 800	43	101	75	100	23 500
*630	135	115.8	102 000	60	118	73	100	15 575

*Natural draft, fan not running.

In later experiments made with a view to increasing the efficiency of the towers, the quantity of air was not measured but the following results were secured in which it is to be noted that the temperature of the outgoing air is only 3 deg. F. below the temperature of the inflowing water. This test was made from a large installation consisting of a special Wheeler-Balcke forced-draft tower.

Water.	Gal. per min.	3200
	Temp. in	109 deg.
	Temp. out	97 deg.
Air.	Temp. in	91 deg., humidity 59 per cent.
	Temp. out	106 deg., humidity 100 per cent.

That it is possible to cool water below the temperature of the air, is evident. For example, take a day during which observations show a temperature of 90 deg. F. and a relative humidity of 50 per cent. The temperature of the dew point is about 68 deg. F. Adding 20 deg. F. to this we would get a final water temperature of 88 deg. F. The atmospheric conditions stated above are usually dry. The monthly average per cent of humidity of localities in this country will vary between 60 and 80 per cent. Standard cooling tower specifications are, therefore, based upon a temperature of 75 deg. F. and 70 per cent relative humidity.

The importance of securing the lowest practical temperature of cooling water is well illustrated by assuming an installation of a cooling tower in connection with a turbine, where each additional inch of vacuum is significant. A difference of 10 deg. F. lower initial temperature of the circulating water in a surface condenser may mean the difference between a vacuum of 27¾ in. and a vacuum of 27 in. Knowing the curve of performance of the turbine, also the evaporation per pound of coal in the boiler room and the cost per ton of coal delivered at the plant, it is quite simple to estimate the saving in terms of coal cost per year, due to ¾ in. increased vacuum.

Some of the most significant cooling tower installations recently made are those where low-pressure turbines, condensers and cooling towers have been purchased in connection with old noncondensing reciprocating engines. The capacity of such plants is almost doubled with the same boiler room equipment and a vacuum of 27 in. in summer is quite possible, with 28 in. during the colder months of the year. In such cases, if the cooling tower is of the forced draft type, it can be operated as a natural draft tower during the colder months, thus saving the power necessary to operate the fans. In most instances the power required to drive the fans will not exceed 1½ per cent of the plant output.

Flow of Water in Pipes

Figuring the Discharge When Pipe Varies in Size. By J. W. Ledoux

THE problem given in Practical Engineer of Jan. 15, page 134, is, in the writer's judgment, very important, and its solution should be indicated clearly, as engineers and other practical men frequently find the necessity of solving many cases of this kind. The principle to be used is well described on pages 16, 17 and 19 of the No. 6A circular of the Simplex Valve and Meter Co., of Philadelphia, Pa. The flow of water through a combination of pipes of different sizes, laid in tandem, depends upon the following elements.

If we let H be the total head to be consumed, this total head is made up of the sum of the heads used up in each element of pipe. In the first place there is the loss due to entrance, velocity and friction. In the second pipe, if it is larger in diameter the loss due to entrance can be ignored, but if it is smaller this loss has to be taken into account again; the velocity head is used only once and is determined from the velocity in the smallest pipe in the system, and the sum of all these heads is equal to the total head. The head due to velocity can only be determined by knowing the quantity of water flowing, which when once found will be the same in every part of the pipe combination, and then the veloci-

ties can be readily calculated from the simple rule that:*

Velocity in the pipe in ft. per sec. = gal. flowing per 24 hr., divided by (3530 times diam. of pipe in inches squared).

With this velocity known, the velocity head = velocity squared divided by 64.4. And when the velocity head is known, the entrance head can be taken as one-half the velocity head.

Flow of water in long pipes is determined approximately as follows:

Gal. per 24 hr. = square root of ft. head lost in friction per 1000 ft. of pipe, times a coefficient which depends on the diameter of the pipe as follows: For 4-in. pipe, coefficient is 59,000; for 6-in., 162,500; for 8-in., 333,000; for 10-in., 582,000; for 12-in., 918,000; for 16-in., 1,880,000; for 20-in., 3,290,000; for 24-in., 5,180,000; for 30-in., 9,060,000; for 36-in., 14,300,000; for 48-in., 29,350,000; for 56-in., 43,150,000; for 60-in., 51,200,000; for 66-in., 65,000,000; for 72-in., 80,800,000.

In the problem, there is 5000 ft. of 20-in. pipe and 12 ft. of 12-in. pipe at the end with a 12-in. valve, the reservoir pressure being 80 lb. per sq. in. in or about 185 ft. head. As the 12-in. pipe is so short, it may well be treated as a 12-in. orifice, since long pipe formulas would not apply, and the flow would be:† Gal. per 24 hr. = square root of head lost in 12-in. pipe, times 2,610,000.

This equals the flow in the 20-in. pipe, which is: Gal. per 24 hr. = square root of head lost in 20-in. pipe times 3,290,000.

The total head lost will be that for the 12-in. section plus that for the 20-in. section and equals 185 ft. From these 2 equalities we find that the head for the 12-in. = 1.59 times the head for the 20-in.; head for the 20-in. = 5 times the friction head per 1000 ft., as the 20-in. pipe is 5000 ft. long; therefore, 6.59 times friction head per 1000 ft. for the 20-in. pipe = 185, or the head loss per 1000 ft. of 20-in. is 28.1 ft.

Using this value we find the flow per 24 hr. in the 20-in. pipe is 17,440,000 gal. And from this the rule for velocity gives 12.35 ft. per sec., which works out the velocity head = 2.4 ft., and the entrance head would be half that, or 1.2 ft., a total of 3.6 ft. lost in velocity and entrance. This is for the long line, and for the short 12-in. section, the velocity loss is negligible, and the entrance head is taken care of in the orifice calculation. Correction for this 3.6 ft. loss of head would make the flow 17,200,000 gal. per 24 hr., which is not sufficient difference to warrant any correction, for, as the rules are based upon experiments, an error of from 1 to 5 per cent is to be expected.

For straight 5000 ft. of 20-in. pipe, the flow would be increased to 20,000,000 gal. per 24 hr., and with the combination described it would make no difference whether the short length of 12-in. pipe were on the upstream or downstream end.

The 12-in. pipe being only one length, is entirely too short for use of long pipe formula, and the flow through it would be approximately the same as if the pipe were short enough to be considered a 12-in. orifice, which may be taken as approximately $Q = 2{,}610{,}000\sqrt{h}$

Assuming this to be true, we can solve the problem under consideration as follows:

$$Q_{12} = 2{,}610{,}000\sqrt{h_{12}}$$

and

$$Q_{20} = 3{,}290{,}000\sqrt{h_{20}}$$

in which h_{12} = the entire loss of head through the 12-in. short pipe, and

h_{20} = the loss of head through each 1000 ft. of 20-in. pipe.

Q_{12} = the flow through the 12-in. pipe, gal. per 24 hr.

Q_{20} = the flow through the 20-in. pipe, gal. per 24 hr.

Then as the 20-in. pipe is 5000 ft. long, we have $5h_{20} + h_{12} = H$, but as the total head is equal to 80 lb. pressure equivalent to about 185 ft., $H = 185$.

As the flow through the 12-in. pipe is equal to the flow through the 20-in. pipe,

$$2{,}610{,}000\sqrt{h_{12}} = 3{,}290{,}000\sqrt{h_{20}}$$

Therefore, $h_{12} = 1.59\ h_{20}$, and by substitution,

$$1.59\ h_{20} + 5\ h_{20} = 185$$

or $h_{20} = 28.1$ = the loss in feet per 1000 through the 20-in. pipe.

Therefore, $Q_{20} = 17{,}440{,}000$ gal. per 24 hr., but as we have not yet taken into account the velocity head through the 20-in. pipe, we find by calculation as described above, that the velocity is 12.35 ft. per sec., and therefore the velocity head is equal to 2.4 ft., and the entrance head lost, would be 1.2 ft., or a total head lost in velocity and entrance of 3.6 ft. This will apply only to the long line of pipe, as the short length of pipe has been figured as an orifice, and therefore, the entrance head has been taken into account in the formula. Making this correction of 3.6 ft. for the 20-in. pipe, would reduce the flow to 17,200,000 gal. per 24 hr., which is not sufficiently different from the results of the other calculation to warrant any correction.

If this were simply 5000 ft. of 20-in. pipe, the flow would be increased to about 20,000,000 gal. per 24 hr., and with the combination described it would make no difference in the results whether the short length of 12-in. pipe were on the upstream or the downstream end of the 20-in. pipe.

---

*As formulas these rules become:
Q = gal. per 24 hr.
D = pipe diam., inches.
V = velocity in pipe, ft. per sec.
h_v = velocity head.
h_e = entrance head.
h_f = friction head per 1000 ft. of pipe.
C = coefficient for figuring Q.

$$V = Q \div (3530\ D^2)$$

$$h_v = V^2 \div 64.4. \qquad h_e = h_v \div 2$$

$$Q = C\sqrt{h_f}$$

†Working with formulas, the computation is as follows, symbols as before:

$$Q_{12} = 2{,}610{,}000\ \sqrt{h_{12}} = Q_{20} = 3{,}290{,}000\ \sqrt{h_{f20}}$$
$$h_{12} = 1.59\ h_{f20}$$
$$5h_{f20} + h_{12} = 185$$
$$5h_{f20} + 1.59\,h_{f20} = 185$$
$$h_{f20} = 28.1$$

$$Q_{20} = 3{,}290{,}000\ \sqrt{28.1} = 17{,}440{,}000 \text{ gal.}$$
$$V = 17{,}440{,}000 \div (3530 \times 20^2) = 12.35 \text{ ft. per sec.}$$
$$h_v = 12.35^2 \div 64.4 = 2.4 \text{ ft.}$$
$$h_e = 2.4 \div 2 = 1.2$$
$$h_v + h_e = 2.4 + 1.2 = 3.6$$
$$\text{Corrected } 6.59h_{f20} = 181.4$$
$$h_{f20} = 27.6 \text{ ft.}$$

$$Q_{20} = 3{,}290{,}000\ \sqrt{27.6} = 17{,}260{,}000 \text{ gal.}$$

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Tubes and Columns

IN THE article entitled "Boiler Accessories," in the Jan. 1 issue, page 26, the author says, in regard to the location of the water column: ". . . while others prefer to place it higher so that when water appears in the glass there will be a safe depth of it over the flues. . . . valves or plug cocks should not be placed in the column connections. . . . and it is advisable to blow the column out at least once a day."

I would like to make a few comments on all of those statements. I have always thought that to place the column so that when water appears in the glass there is a few inches over the tubes, is not only a foolish practice but also misleading and dangerous. It allows room for a little "guessing" on the fireman's part and guessing should be entirely eliminated from a fireman's vocabulary.

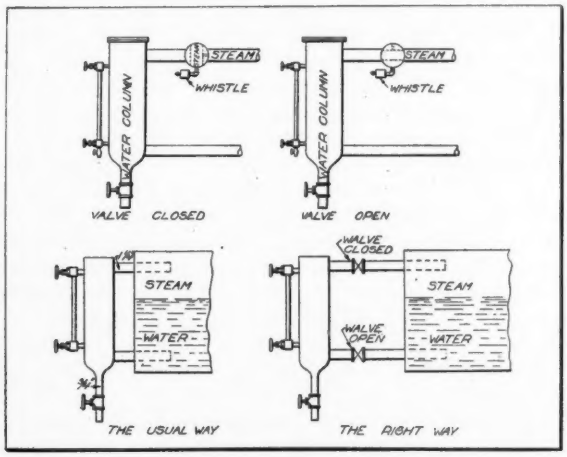


FIG. 1. WATER COLUMN CONNECTIONS

For instance, when the load is heavy and the pump is bucking and is just able to hold water by fits and starts, the water hangs just visible in the glass and occasionally goes out of sight. Then the fireman consoles himself with the thought that there is still 3 in. over the tubes. He guesses it will show up in a minute, as he saw it only a few minutes ago. He keeps stretching the time (I've been there myself) that it is due to show up according to his guessing and possibly when the load goes off, and the pump works a little better, it does show up and then he guesses it didn't go low enough to burn the tube. No one knows whether the tubes got burnt or not and in a boiler thus equipped, there is no possible way of knowing; while, if the bottom of the glass had been on a level with the top of the tubes, the fireman could see when the water was low and if he didn't stop firing then he would have no complaint to make if he attended his own funeral the next day. A complaining fireman is a nuisance.

The next is a flat statement that "valves or plug cocks should not be placed in the column connections." According to my notion, valves should always be placed in the column connections; if not in both, then by all means, in the steam connection. The only argument I ever heard against these valves is that someone might forget and leave them closed. Why not do away with the boiler blowoff valve for fear someone would forget and leave it open?

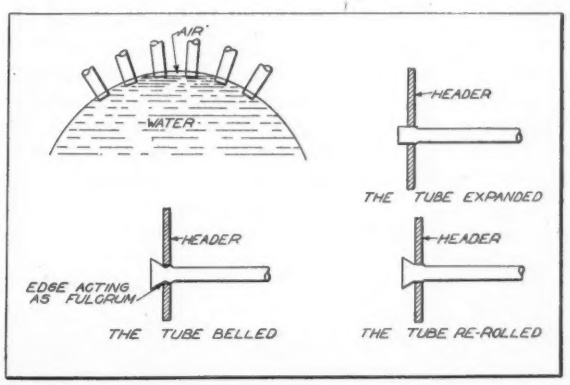


FIG. 2. AIR TRAP CAUSED BY BELLING TUBES AND EFFECTS OF ROLLING AND BELLING TUBE ENDS

Insurance companies don't want valves in the column connections, on the theory that they are unsafe. Their arguments have no weight if you take into consideration the fact that explosions mean business for the insurance companies. I always think of that when I hear inspectors argue against these valves on the water column.

About a year ago, I had 4 water-tube boilers to nurse and care for and they had no valves that they could possibly do without in accordance with the contract. The water was very muddy and about every week the water in the glass would get sluggish and we would know that the column was about full of mud again. Why didn't we blow it out? We spent most of our time in blowing down water columns, but the blowoff pipes were ¾-in., while the steam and water connections were 1¼-in. The 1¼-in. steam connection seemed well able to supply the little ¾-in. blowoff pipe without using the bottom or water connections, at all. It seems to me that if there are to be no valves in either connection, the blowoff pipe should have a capacity equal to both the steam and water connection in order to blow them both down

at the same time. Wouldn't a 2-in. pipe for a water column blowoff look awful on a boiler front? I leave it to you.

For the proper blowing down of the column, only the valve in the steam connection is necessary; but it is well to have one in the water connection, also, so that the column could be shut off for repairs. It must be remembered that there are 3 test cocks on the column, 2 valves on the glass, one valve on the blowoff pipe and a valve on the glass blowoff or drain pipe and any of these are liable to start giving trouble or leaking. It's rather expensive to have to cut a boiler out and cool it down in order to replace or regrind the seat of a test cock. I have had to kill a boiler because a tee, in the ¼-in. line to the gage from the top of the column, developed a sand-hole. If a valve in each connection is likely to give trouble, put a plug valve in the steam connection with an alarm whistle on it that would whistle all the time the valve was closed. This could be done by drilling a small hole from one side of the plug to the opening in the center of the plug and a hole in the side of the valve to which the whistle is attached.

In the Jan. 15 issue, page 132, Geo. H. Wallace makes some statements that I can't let pass. C. M. L. asks, "Why are some of the tubes in the mud drum of a Stirling boiler beaded; should the ends of tubes and nipples be flared or beaded, and why?"

A few of the highest tubes in the mud drum are always beaded by the erecting men. This is done to prevent air pockets forming in the top of the mud drum as the boiler is filled with water. The air would hold the water away from the shell and might cause it to burn before the circulation of the water removed this air, if it would remove it. I don't know about that, as they always bead some of the tubes.

Another good reason for beading some of them is that if the air pocket formed when the boiler was first filled for the hydrostatic test, some of the tubes would be protected by air and no water leak would show up. If 2 reasons aren't enough, the third one is, that if air remained in the boiler during the hydrostatic test, it would take about 4 times as long to pump up a pressure with a hand pump.

Speaking of beading or flaring tubes in water-tube boilers, Mr. Wallace says, "it is general practice . . . to flare them ⅛ in. and roll them." It used to be general practice to bead them all and they used to thread some of them in fire-tube boilers. This was done to prevent them pulling through the head. They got over that and now they first roll them and then flare or bell them and then roll them again. Probably there is a good reason for belling them, but I have never been convinced of its value. Does the flare make them tighter? No, it loosens them and they immediately have to be rerolled. Does the flare prevent them pulling through the header? That's foolish. I'm speaking of a water-tube boiler where the tube ends are not exposed to the fire. Belling or flaring water tubes looks like an old custom that we haven't had the nerve to drop yet. If I'm wrong, I'd like to hear from Mr. Wallace or any other authority on this subject. I'll try to show by sketches exactly what I mean.

The tube, after the first rolling, is perfectly tight. Then the belling takes place. The pounding on the beller tends to disturb and loosen the tube and the bending back of the tube, with the outside edge of the hole through the sheet acting as a fulcrum, tends to raise part of the tube off the seat; consequently, the tube leaks and has to be rerolled. This unnecessary bending of the metal in the tube can do it no good.

F. R. Daly.

A Central Station Argument

The central-station solicitor will, in an effort to land business, sometimes resort to claims that contain considerably more than a chemical trace of hot air. When this is the case, one may be assured that it is not due to ignorance, for the central-station solicitor is, as a rule, thoroughly up on things pertaining to power generation and when he hands out a line of talk that does not fit the facts in the case, he is guilty of an attempt to deceive.

We are all familiar with the argument advanced by the central-station man when he proposes that we sign the contract that furnishes us current at 1½ cents a kilowatt-hour, shut down our plant and be happy ever after.

Whatever there may be of merit in the average central-station man's "selling talk" when trying for the dismantling of an isolated plant, it would be hard to beat the talk advanced by the booster of a municipal power plant in this locality when he tried to convince the people, through a daily newspaper, that electricity used as fuel, at 3 cents a kilowatt-hour, can compete successfully with natural-gas at 75 cents or $1.00 per 1000 cu. ft. This booster who happens to be consulting engineer for the plant in question, states that "there are 3200 heat units in a kilowatt of electricity," that "with gas at $1.00 per 1000 cu. ft., an equal amount of heat would cost a fraction over 3 cents, since it would take 3 and a fraction cubic feet to produce 3200 heat units. But at best, natural gas produces only 750 heat units, which means 3-cent electricity is cheaper than our best gas at a 75-cent rate."

Now, it is pretty well established that a kilowatt-hour of electricity is equivalent to a little over 3400 heat units, also, that the natural gas supplied to consumers hereabouts develops very nearly 1000 heat units per cubic foot. Natural gas developing only 750 heat units is considered poor gas.

With a knowledge of the rudiments of arithmetic, anyone can prove that 1 cent's worth of natural gas at $1.00 per 1000 cu. ft. is 10 cu. ft. and will furnish 10,000 B.t.u., which is as many heat units as are contained in 2.94 kw.-hr. of electricity or at a 3-cent rate, 8.82 cents' worth. Electricity may have advantages over natural gas as a domestic fuel, but economy is certainly not one of them. C. O. Sandstrom.

Friction and Engine Losses

I note that in the Jan. 15 issue, Mr. Wallace states in his letter: "The writer has changed soft packing all around on a compound Corliss engine, but the log did not reveal any change in general economy."

There may have been a slight improvement due to this change, but the influence of a packing is usually so slight that almost any other increase in friction would offset the benefits of better packing.

About the best way I know of for noting whether or not new packing is consuming more or less friction is to take the "stopping time" of the engine after closing the throttle valve, both before the new packing is put in and after it is in. Starting from normal speed it is evident that if there is more friction the engine will stop more quickly than if there is less friction. The engineer should use such packing and such lubricant that the stopping time becomes a maximum.

N. G. NEAR.

Corliss Engine Cards

THE ACCOMPANYING cards were taken from 2 very old Corliss engines. Card No. 1 was taken from an old George H. Corliss engine with the large loose form of wristplate shown by the drawing. While card No. 1 shows most excellent lines, the one peculiarity of the high initial pressure on one side was puzzling at first. Although this same condition is frequently found, it was in a different way in this engine. When the whole gear had been lined and squared up, or trained, as it is usually called, card No. 1 was taken, and we found that we had this peculiar steam distribution; while a fine outline for a card, the slow admission on the one end and the quick on the other with its high initial pressure, was the puzzling part.

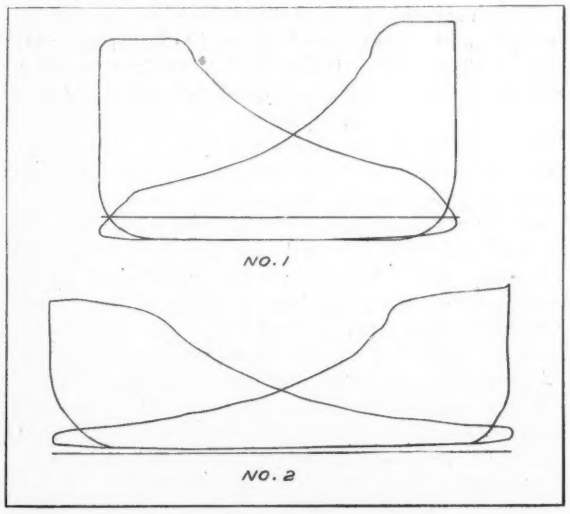


FIG. 1. CARDS FROM OLD ENGINES

So we proceeded to find what was causing this. The rocker arm, M, was found to travel only on the one side of a vertical line, and this tends to throw the valve gear out. This was corrected, and yet the card was not perfect. While the valve caps Nos. 1 and 2 were off for inspection as to the marks, we discovered that the one valve chamber was much larger in diameter than the other, and it was impossible to have the outside links a like length and perfectly trained, as we would expect to have on a true gear. This was caused by the valve chamber being bored out larger at the factory; of course, we had to set the gear by the indicator, and by so doing produced an excellent card.

Card No. 2 was taken from another old time Harris engine, 14 by 36-in., running 90 r.p.m., 540 ft. piston speed, which is not a great piston speed, yet this engine shows a falling away of the admission pressure and this was caused by the steam line and the type of steam separator that was being used. It is usually expected that a good separator will form a reservoir for the cylinder supply. The separator was one of the types with baffles separate from the outside body and set in; so we took the baffles out and corrected the steam line.

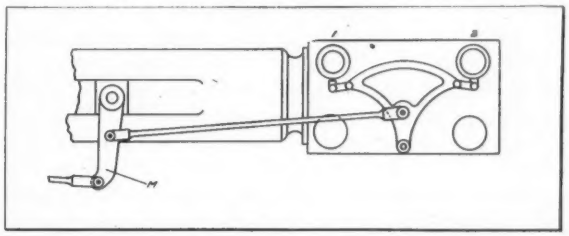


FIG. 2. DIAGRAM OF OLD CORLISS ENGINE GEAR

The loss from small, cramped steam and exhaust lines is much greater than most engineers realize, and we have many installations running that would soon pay for a new steam and exhaust line by saving in steam or coal. This is shown by card No. 2. The steam and exhaust lines were too small and both obstructed. I can recall one large engine that was considerably overloaded and the plant was short for power. We removed an exhaust header, which was all right when the plant was first built, but became too small as the load was increased. and by this we gained sufficient power to run on. It is not always the engine.

C. R. MCGAHEY.

The Factory Fire Chief

THE EDITORIAL, page 99 of the Jan. 1 issue under the above caption, suggests the following comment:

City fire departments are required to drill every day, in addition to the many alarms to which they respond. By doing this, every man and horse knows just where his place is and what is expected of him. The factory fire chief should proceed along the same lines if he wishes to have an efficient company. It would be impossible to drill every day, but he should have drill once or twice a week until the men are thoroughly familiar with the apparatus.

The number of men required to handle the apparatus should be determined, that number selected from the force, and no one else permitted to handle any part of the apparatus except as a substitute. Each man should be appointed to a certain position and always work in that position. This will prevent the men from getting in each other's way. It is also necessary that every man obey the orders of the chief. Sometimes false alarms are turned in for the purpose of drills; this is not a good plan, as it tends to discourage the men. A better way is to use an alarm which they will all know is for drill purposes only. Much can be done with a volunteer company in the way of skill if they are properly trained. Last spring, the writer was a delegate to a Volunteer Firemen's Convention. Among the other field events was a hose race in which 18 men pulled a hose reel 250 yd., coupled onto a plug, unreeled 4 lengths of hose and put on the nozzle in 37 sec.

Local laws govern the use of fire escapes and, to some extent, the construction of the building and the kind of fire protection required. In nearly every building will be found portable chemical extinguishers. This is a simple and reliable instrument for dealing with a small fire. The tank contains about 3 gal. of water, into which 1½ lb. of bicarbonate of soda has been dissolved. In the top of the tank is an 8-oz. bottle in which is placed 4 oz. of sulphuric acid. When the extinguisher is held upright, the heavy lead or porcelain stopper fits the top of the bottle closely and the chemicals cannot mix or evaporate; but when the position of the tank is reversed, the stopper drops down, allowing the acid to trickle out slowly and mix with the charged water. This generates a gas at a pressure of 80 to 120 lb., which throws a small stream for considerable distance. The stopper and nozzle of the hose are an important part of the apparatus, and should be made of lead to prevent corrosion from the acid fumes. Sometimes a porcelain stopper is used. In using this extinguisher, always have hold of the nozzle before upsetting the tank, to prevent getting a dose of chemicals in the face. The Board of Fire Underwriters requires that chemical extinguishers must be inspected and recharged yearly. To inspect and recharge, the extinguisher should be discharged as in use at a fire to ascertain if it will work. Where there are many in use, it is often found that some of them will not discharge when upset. This may be due to the stopper sticking, nozzle being plugged up or the fact that at some time the tank was tipped over and quickly uprighted again, which allowed enough acid to escape to neutralize the soda. To prevent this, the extinguisher should always be hung on the wall. Last spring, in testing 140, we found 8 that would not work, although all are hung on the walls or posts.

This type of extinguisher cannot be used for putting out fire around electrical machinery, as the water might do serious damage, and also the operator would be liable to get a shock. For this purpose a dry powder is used or a liquid extinguisher called Pyrene, a volatile liquid which is used in an apparatus not unlike an oil squirt gun. Pyrene is not a conductor and may be played directly on live wires without danger of shock.

Usually the fire pump in the engine room is of the reciprocating type of massive construction and so designed that it cannot easily get out of order. In some plants, centrifugal fire pumps are used. The fire pump should be kept in good running order so that it may be instantly started if necessary. In some plants, the pump is under steam through a governor all the time and works at a slow speed to keep the pressure up, the water being bypassed to the suction or used around the building. When the fire hose is turned on, the sudden drop in pressure will cause the governor to open and speed up the pump.

In other plants, the pump is not operated continuously. In this case, it should be run for ½ hr. about twice a week to insure its being in good order when wanted. Fire hose is expensive, and should be well taken care of, as it deteriorates more from standing idle than from use. After being used, it should always be thoroughly dried out. If this is not done, the moisture will cause the rubber lining to become brittle and crack. This is done in all fire departments either by suspending from one end in a tower or placing on a drying rack. The hose should not be allowed to stand on reels for more than 2 months without being laid out and having water run through it. It should then be dried out and not placed in a hot place if it can be avoided, as the heat shortens the life of the rubber. It is worth while to take this trouble for it increases the life of the hose and insures its being in condition for use when wanted in an emergency. The standard fire hose usually consists of a 3-ply rubber lining covered with a single or double cotton jacket. Sometimes these 2 jackets are made separately, but it has been found in practice that they should be interwoven together. Where they are separate, the pulsation of the pump will cause the inner jacket to work within the outer jacket, which action will wear it through; also, water leaking through a hole on the inner jacket will follow along to a weak spot in the outer cover and break through more quickly than it would if both were woven together.

In certain classes of buildings, the hose may be allowed to remain in the reels for years without being used. In this case, a hard woven linen hose without rubber lining may be used. It is impossible to make this as tight as cotton rubber lined, and any dry linen hose will "sweat" some when water is first turned on. The material in the fabric, however, is such that it quickly swells from moisture, making it tight.

The standard cotton rubber lined fire hose is tested to withstand a pressure of 300 to 400 lb. This is much higher than required for a private department and would require 4 or 5 men to hold the nozzle of a 2½-in. hose line. The usual pressure is about 100 lb. In fighting a small fire, especially by an inexperienced company, the excessive amount of water used will oftentimes do more damage than the fire. This can be prevented to a great extent by using a shutoff nozzle instead of a plain nozzle. In ordering new fire hose, especial attention should be given to the couplings. Unfortunately, there has never been a standard thread which was universally used in connection with couplings and nozzles. Different manufacturers have used a standard of their own, and what is standard in one part of the country may not be in another part. In consequence, a great confusion exists. This applies to city departments as well as to private departments. A few years ago a serious fire broke out in a large city. A neighboring city was called on for help, but when the department arrived it was found that the thread of the hose couplings and fire hydrants were not the same and the hose could not be used. In ordering either hose or nozzles, the best way is to send a sample coupling to show just what is wanted. When this cannot be done, the outside diameter of the thread, the pitch and length of thread should be sent.

In many buildings, a sprinkler system is used, consisting of a network of piping near the ceiling, in which a high water pressure is carried. On the branch pipes, sprinkler heads are placed about 12 ft. apart each way. In these heads is a fusible seal, which melts at a temperature of about 155 deg., and in melting allows the heads to open. The fusing point of the seal is above the temperature of the room; but should a fire break out or the room become overheated from any cause, the excessive heat, which is always greater near the ceiling,

will melt the fuse and the room will be sprinkled and the fire held in check. An automatic alarm gives warning when the sprinkler head opens. After the fire is out, the branch valve is closed and a new fuse put in.

If there is any doubt in the mind of the factory fire chief as to just how to organize his fire fighting force, it would be wise to go to the nearest chief or other officer of a good paid department, who will be only too glad to give all the information he can to help the factory fire chief organize his men, as it may mean a great deal of help to the city department in case of a bad fire.

J. C. HAWKINS.

Wrong Method of Blowing Down Boilers

IN THE Feb. 1 issue, J. E. K. asks why his method of blowing down boilers is wrong.

There are several good reasons why his method is not only wrong but extremely dangerous. In the first place, the blowoff pipe probably has one or more elbows in it, and when the pressure is suddenly released, the contents of the pipe will have a tendency to continue in a direct line instead of making the turn, thus rupturing the pipe at the elbow. If this does not happen, the matter which clogged the pipe is apt to become lodged in the elbow or even in the valve or cock and instantly stop the flow, thus causing a severe water hammer.

Then, again, as I understand his letter, the blowoff pipe was red-hot. Now, it would be extremely foolhardy to remove the obstruction and allow the water to come in contact with the pipe when it is in this condition, and especially when it is under pressure; if it did not cause an immediate rupture it would weaken the pipe so that that would be the result eventually.

Of course, his method is practiced daily throughout the engineering world; but it is in direct conflict with the now almost universal rule of Safety First.

R. M. PACKINGHAM.

Reactance Coil Design

IN A recent issue, there appeared an article by V. E. J., in answer to questions by C. D. These answers are so obviously incorrect and misleading that they deserve comment.

The method of synchronizing under discussion was taken up on page 131 of the July 18, 1914, issue of the Electrical Review and Western Electrician. Only one phase is used, the unbalancing in synchronizing being negligible and the complications following the use of 3 phases unwarranted.

The formulas and data given to compute the reactance coils for synchronizing are not exact. By the use of Electrical Machine Design by Gray, the Inductance of Coils by Brooks & Turner (University of Illinois Experimental Station Bulletin No. 53) and section 5 of the Standard Handbook for Electrical Engineers, C. D. will be able to find all the information required for the proper design of these coils.

I wish to call particular attention to the value of the current density allowed by V. E. J., that is, one circular mil per amp. of current. This would mean that a No. 14 B. & S. gage copper wire would be allowed to carry 8200 amp. and a No. 0000 wire, 423,000 amp., which values are 512 and 1355 times the maximum allowed by the Underwriters' rules.

As the current required to fuse a copper conductor d in. in diameter is equal to the product of 10,244 times

$$3$$

the — power of d, a No. 14 wire will fuse at 166 amp.

$$2$$

and a No. 0000 at 3200 amp. or at 0.02 and 0.0075 respectively of their allowable density according to the figures of V. E. J.

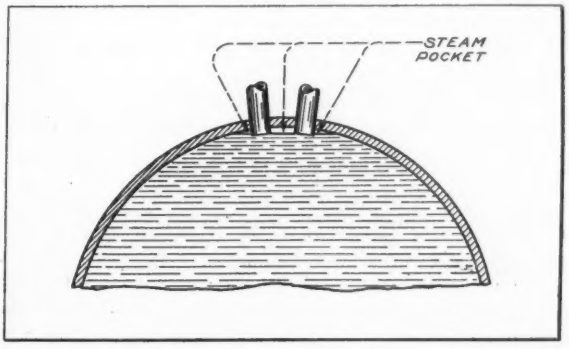
As machine design is my hobby I would, if C. D. still desires, be glad to help him on the design of these coils.

H. E. WEIGHTMAN.

Tubes of a Stirling Boiler

ON PAGE 131 of the Jan. 15 issue, pertaining to the tubes of a Stirling boiler, the writer is somewhat surprised at the answer given to question No. 3: "Why are some of the tube ends beaded in the mud drum of a Stirling boiler?"

The answer in brief stated that there was no particular reason why the ends of some of the tubes in the mud drum should be beaded, as the ends of the tubes in the upper drum are only flared and expanded. It is my experience that it is very essential that several of the tube ends in the rows which enter the mud drum at the highest point should be beaded, for the following



LOCATION OF STEAM POCKET WHEN NO TUBES ARE BEADED

reason: to avoid the formation of air pockets which would take place around the tube ends that have a projection of not less than ¼ in. when filling the boiler with water, which, after the boiler was placed in service, would become steam pockets (see figure), thereby exposing the ligament between the tube holes to overheating and possible fracture, or causing grooving of the plate around the tube ends which would eventually result in fracture, and it can easily be seen that it would be almost impossible to make a permanent and satisfactory job of repairs should some of the ligaments between the tube holes fracture, the upper portion of the mud drum being honeycombed with tube holes; furthermore, the efficiency of the tube ligament in this type of boiler is only 0.458 as compared with the solid plate, and it would need the failure of only a few of the ligaments between the tube holes in the same row to cause disastrous results. It

can now be plainly seen that beading some of the tube ends in the lower drums, allows the air bubbles which would collect around the projected tube ends, free escape through the tubes beaded to the upper drums.

Some of the early built boilers of this type did not have any of the tube ends beaded, and defects as stated have been experienced, but of late years trouble of this nature has been eliminated. Nevertheless, the lower drum of this class of boiler provides a great field for close observation and study. I might say that the Erie City Boiler Works beads several of the tube ends in the lower drum of its vertical water-tube boilers for the same reason. I also notice that the person who has answered the questions under consideration is of the opinion that it would be of assistance in the circulation of the water in the boiler to bead the tube ends, by so doing considerably reducing the frictional losses occasioned by the projection of the tube ends. Here again I differ from him, as I think that the resistance offered by the projection of the tube ends in this type of boiler, if not allowed to project more than ½ in., is so small as to be of no account; furthermore, if the feed water contains only a slight amount of solids, they are invariably found to adhere in the form of scale to the projected tube ends, which they would not do if there was any appreciable resistance set up to retard the flow of circulation. Another statement made in answer to the question referred to is, that if the tubes were beaded, it would be impossible to remove them without injuring the tube holes in the sheet, and I would say that to my personal knowledge many beaded tubes have been satisfactorily removed and replaced by new ones without causing any distortion of the sheet or damage to the tube holes, more especially in the Cahall vertical tubular boilers, which have all the tube ends beaded in the top and bottom drums. BOILER INSPECTOR.

Care of Heating System

I HAVE read the letter of R. L. in the Feb. 1 issue, relative to trouble with his heating system.

Heating systems, as a rule, seem to be a secondary matter with most engineers; they do not overhaul, repair and take the same care of them each year as they do of the rest of their plants, letting that part go until trouble appears, which, of course, is in cold weather, and at a time when good heating service is needed the most and when they have the least time to make repairs.

In the plant where I am employed, we have 50,000 ft. of radiation besides hot water tanks, etc. I always make it a point to overhaul thoroughly vacuum and boiler feed pump each summer. I also thoroughly clean all motor seals and thermostatic valves on the return end of radiators as, if there are leaks of steam at these points, it will break up your vacuum on the suction line of the pump and thus retard the circulation of steam. In this plant, our buildings cover 3 or more blocks, and the plant is just about centrally located. No matter how severe the weather is, we never carry above atmospheric pressure on the mains at a point just beyond the low-pressure side of the pressure reducing valve, and I never use any cold water in the condenser on the suction line of the pump. My returns come back at a temperature of 185 to 190 deg. F., and I am able to maintain a vacuum of 5 to 7 in., which is very good with that temperature, and your system will have to be pretty tight.

Now, if R. L. will see that his pump valves and seats, packing, etc., are in good order, get a vacuum on his system and go around and test for leaks at valve stems, unions, etc., to radiators and be sure that all interiors of valves and traps on the return end of radiators are clean and properly set, he will be able to heat his building without carrying any pressure above atmospheric, except on the line running to drying boxes.

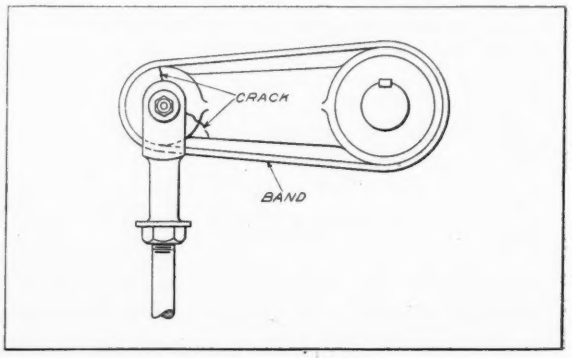
If it is convenient, I would run a separate line to these boxes, install a pressure reducing valve on it and a good return trap and carry just enough pressure that the trap easily handles the returns, which would require 3 or 4 lb. of pressure.

If he wants to discharge these returns into the suction line of his vacuum pump, he will have to use a vacuum return trap, of which there are good ones on the market, as the common trap is apt to leak steam.

J. H. NORTON.

Repair of Corliss Valve Gear

THE ENGINE was running as usual when the hook spring holder broke off and left the hook free to swing. The trip lever on the hook came in contact with the plate block on the arm, on its downward movement, and broke the arm, as shown in the sketch, and bent the dashpot rod. The arm was temporarily repaired by shrinking an iron band around it to hold it together.



CRACKED ARM OF CORLISS VALVE GEAR, AND METHOD OF REPAIR

The nut that holds the hook on had to be reduced to half its thickness so as to pass the band. The band held the arm together until a new one was received from the maker. The cracked arm is to be welded together, as the band is working loose, and is to be kept in reserve.

L. K.

Feed Water Temperature in Massachusetts

IN THE Feb. 1 issue, W. E. Chandler states that Massachusetts requires that the feed water must enter the boiler at 150 deg. F. Massachusetts only requires a usual feed water temperature of not less than 120 deg. F. when the pressure allowed exceeds 25 lb. per sq. in. J. L. TOLMAN.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Storage Battery Operation

KINDLY EXPLAIN the proper method of charging a 60-cell battery, the charging rate to be 2 amp. and the rate of discharge, 1 amp. for 20 hr. These cells are to be charged by an 80-v. direct-current compound-wound generator.

2. How many 16-cp. lamps should be used as a resistance?

3. How should they be connected?

4. Kindly make a diagram of connections, including a Gould Storage Battery Co.'s switchboard, and showing proper point of connecting a one-way reading ammeter. W. B. E.

A. It is not usually good policy to charge storage batteries from compound-wound generators, unless special care is taken that the battery voltage at no time

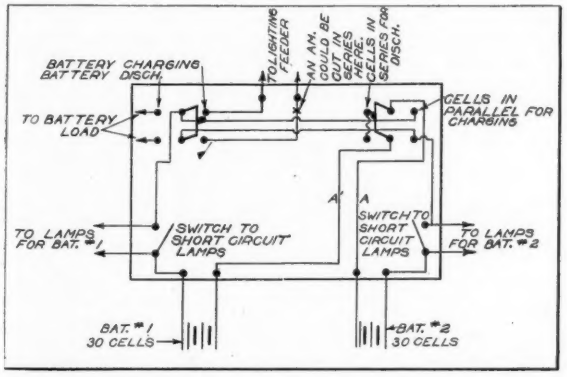

BATTERY CHARGING BATTERY DISCH.
TO LIGHTING FEEDER
AN AM. COULD BE CUT IN HERE
CELLS IN SERIES FOR DISCH.
TO BATTERY LOAD
CELLS IN PARALLEL FOR CHARGING
A
A
TO LAMPS FOR BAT. #1
SWITCH TO SHORT CIRCUIT LAMPS
SWITCH TO SHORT CIRCUIT LAMPS
TO LAMPS FOR BAT. #2
BAT. #1 30 CELLS
BAT. #2 30 CELLS

FIG. 1. DIAGRAM OF CONNECTIONS OF STORAGE BATTERY SWITCHBOARD

is greater than the generator voltage, and that no current can flow from battery to generator. In your particular case, 60 cells, in order to be charged from an 80-v. circuit, will have to be divided into 2 batteries of 30 cells each. The average voltage of each cell varies from, say, 1.8 to 2.3 v. This would mean a total battery voltage of from 54 to 69 v.—which is sufficiently far below the generator voltage to eliminate any danger of "feeding back." If there is, however, any such danger, it would be advisable to install some type of reverse-current protective switch.

2 & 3. In calculating the number of lamps to be used as resistance in storage battery charging, it is customary to allow 2 v. charging potential for each cell. This would be 30 times 2 or 60 v. total drop across each battery with 80 — 60 v., or 20 v. to be consumed in external resistance. As there is to be a charging current of 2 amp., there will have to be a sufficient resistance inserted in series with the cells to cause a drop of 20 v. with a 2-amp. current flowing. And as 20 divided by 2 equals 10, a 10-ohm resistance having a carrying capacity of at least 2 amp., must be used for each set of cells.

As 16 candlepower lamps are to be used, the calculation is as follows:

Assume 50 w. per lamp. Then 50 divided by 80 equals 0.625 amp. as the normal current carrying capacity of one lamp. Eighty divided by 0.625 equals 128 ohms, the resistance of each lamp. This is somewhat higher on a carbon lamp when cold.

The problem then becomes one of determining how many 128-ohm resistance units will be necessary to produce a total resistance of 10 ohms. One hundred and twenty-eight divided by 10 equals 12.8 units, or say, 13 lamps.

Hence, for each battery of 30 cells, 13 lamps in parallel must be used. Thirteen times 0.625 equals 8.1 amp. carrying capacity. So there is ample cross section of carbon to carry the current.

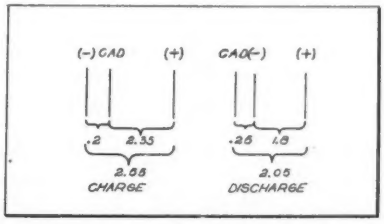


FIG. 2. ILLUSTRATION OF METHOD EMPLOYING THE CADMIUM ELECTRODE TO DETERMINE THE CHARGE AND DISCHARGE OF A BATTERY

You give no data concerning the load on the batteries—but it is evident from the above that if it were possible to reduce the voltage of your generator to from 54 to 69 v., your cells could be charged much more efficiently, as there would be no loss in resistances.

In charging with lamps, no provision is made for maintaining constant current during the charge. These variations are caused by the change in the virtual resistance of the cell from its "discharged condition" to its "charged condition." They are in small sets like yours—not enough to make much difference, but if it is desirable to regulate accurately, it will be necessary to have extra lamps in parallel, arranged so that one at a time may be switched out, thus increasing potential across battery as the charging continues.

4. You do not give sufficient data in regard to the Gould board which you have, to include it in the adjoining sketch; but the schematic nature of the diagram will perhaps suggest the manner of its connection.

This system of connection permits of readily connecting cells in parallel for charging, and also furnishes a convenient means for connecting cells to either charging lines or to their connected load. When cells are discharging, lamp banks, of course, must be short circuited. An additional pair of switches would permit either battery to be charged alone. An ammeter in series as at A and A^1 would be convenient for noting constancy of charging current, and regulating it by means of cutting lamps into or out of circuit.

Perhaps the best way to determine the condition of charge or discharge of a cell, is by means of a cadmium electrode. This is inserted into the electrolyte, being careful not to touch either the + or — plates. On charge there should be a potential difference of 2.35 v. between the cadmium and + plate (charging current still flowing) and a difference of about 0.2 v. between cadmium and the — plates. The cadmium should be positive to the + plate and negative to the — plate. When fully discharged—that is, down to 1.8 v.—the voltage should be,

from cadmium to + 2.05 v.
from cadmium to — 0.25 v.

Cells should, of course, be discharging at normal rate. When cell is discharged, the cadmium electrode will be positive to both + and — plates.

Figure 2 from Lyndon shows these conditions graphically. V. E. JOHNSON.

Water Slip in Pumps

WITH AN inside packed piston pump, how can I tell whether water is slipping past the pistons?

A. Water slip may be caused by one of 3 things. Water slip may be past the pump piston or past the pump valves; or, it may be the passing of water from the suction to the discharge, that is, from one end or side of the pump to the other, due to defective gaskets.

When a pump is in first class shape, it will do the required work at normal speed. As the packing and valves become worn, the water slip will be increased and the pump will be required to operate at a higher speed to give the same capacity.

On a simplex pump, water slip may occur without any change in the operation of pump with the exception of higher speed to make up for the loss due to water slip. This simply calls for repacking the pump piston, examining or replacing the pump valves and seeing that the gaskets on the pump end are in proper shape.

On a duplex pump, water slippage not only necessitates the pump's being operated at higher speed, but also affects the action of pump. The valve movement is such that one side throws the steam valve on the opposite side. If the packing in the pump piston on one side is badly worn, causing water slip, or if the valves on one side are in worse shape than those on the opposite side, the pump will operate irregularly. The side on which the greater water slip occurs will take a long, quick stroke, while the side that has the least water slip will take a short, slow stroke.

To overcome the trouble of water slippage on a duplex pump, it is first necessary to examine both sides, repacking the pump pistons and refitting the pump valves, placing them in first class shape. The pump must be packed evenly on both sides so that the friction on one side will not be greater than that on the opposite side. The valves should also be in the same general condition on both sides of pump.

On either a simplex or a duplex pump, if the pump is of the valve plate and cover pattern, water slippage or loss may occur between the 2 sides or 2 ends of the pump. If the partition in the center of pump, between the suction valves, which divides the 2 sides will not hold a gasket, water will be bypassed, resulting in loss in the capacity of the pump.

DEAN BROS. STEAM PUMP WKS., N. DEAN.

Determining Clearance

IF YOU just took charge of a plant having a high-speed engine, how would you find out the clearance on each end, if there were no marks for striking points and no time to find them, and you had to start up in a few minutes? C. S. T.

A. In taking charge of a new plant, no matter what the capacity may be, one must use his best judgment, as there are no set rules as to procedure. Generally, when a new engineer enters a plant, there is time enough to become, in a way, familiar with at least the general surroundings, which will give him an opportunity to trace out the piping and the necessary valves.

If time enough is permitted, the engine can be looked over if not already in operation. Indeed, if it is in operation, that eliminates much possible trouble for the beginner in that particular plant, as the fact that the engine is running, is sufficient evidence that it will run. But if, as stated in the inquiry, the engine is required as soon as the new man enters the room, he must keep his head and use his best judgment, making note of every little detail that meets his eye or ear. For instance, if the rods and connections have not been disturbed for some time, there is formed a light black coating or hard crust where the nut sets against the adjoining part, and if this coating has been disturbed, it is sufficient evidence that these parts have been moved for some purpose, good or bad, and the newcomer must decide from evidences at hand and also from such knowledge as he may have, as to the conditions accompanying the change of engineers, whether these parts have been moved to no good purpose.

On Corliss engines, look over the valve gear closely for these evidences as described above, although the knockoff rods may have been adjusted frequently for good reasons. In high-speed engines, look over the nuts, etc., in the governor and connections between it and the valve. On all engines (unless of large size, or those having a keyed piston rod in the crosshead) look at the piston rod to see if this tell-tale coating has been disturbed.

This brings the matter up to the question as asked. If the piston rod has been unscrewed, you can generally see the amount by examining the thread closely; but if the rod has been screwed into the crosshead, the clearance cannot be learned so easily.

If the necessary men and means are at hand, it is good policy to turn the engine over by hand at least once, and if no obstructions are encountered, there is "striking" clearance at each end, although owing to large striking clearance in high-speed engines, as a rule, it may not be equal.

If the cylinder has indicator connections, a piece of lead, or strip solder, or even a bundle of fuse wire inserted at the opening before the engine is turned over, will assist in determining the clearance at each end.

Of course, the first consideration is to start the plant, as any delay in starting, on the part of a new engineer, has a tendency to lower his standing as a mechanic, both with employer and employes, and this makes his pathway all the harder.

The writer was once called upon to act as substitute for an engineer who was taken suddenly ill, and entered a strange plant an hour before starting time, with no light but a lantern until the lighting engine was started. There were 2 high-speed engines, one for light and one for power, and to make matters a little worse, the boiler was fed by city pressure and the watchman's wife had died suddenly but an hour before, thus leaving matters somewhat complicated. A hasty but careful examination of the plant as a whole, however, along the lines laid down, gave an idea of about what the plant consisted, and no trouble was experienced except that owing to the watchman's misfortune, the heating plant was not started soon enough. G. H. WALLACE.

Proper Gas Engine Fuel Mixture

How CAN I ascertain the correct mixture of gas with a hand analyzer attached to a gas engine? Would not the water in the muffler absorb enough CO_2 to affect the result?

At what point should I take a sample of gas on a 55-hp. twin cylinder Bruce-Macbeth engine, and why?

What would be an ideal condition beyond improvement? G. C. J. S.

A. A gas engine fuel mixture is correct when all of the carbon monoxide, CO, is converted into carbon dioxide, CO_2, and all the hydrogen has united with oxygen to form water within the engine cylinder. The oxygen for this combination is derived from the air used in the mixture, and neither carbon monoxide, oxygen nor hydrogen should appear in the exhaust.

If a surplus of air is used as is necessary, oxygen will show in the exhaust, in which case you are sure all the carbon monoxide has been burned, and a small loss has taken place because of the surplus oxygen and nitrogen. This surplus has carried away heat from the engine cylinder which should be used for power production.

If there is a scarcity of air, and as a result a scarcity of oxygen, carbon is unconsumed and smoke is the result; this is a sure indication of imperfect combustion. Secure that exhaust, therefore, that shows a slight excess of oxygen and no carbon monoxide, hydrogen or other combustible gases. The percentage of this oxygen should be reduced to the lowest limit, even to the fraction of one per cent.

The water in the muffler of a gas engine will not affect the results of the gas analysis, for this water is hot and hot water will not absorb carbon dioxide. If this water were cold it would not cause error, for the amount of carbon monoxide is so great that the water soon becomes saturated and then no further change takes place, the water addition being small. In the gas analyzer itself, the gas is drawn into the presence of water and little or no loss takes place.

Samples should be drawn from the exhaust pipe of the engine as close to the cylinders as possible. No error will result in throttling engines if this is not done; but in a hit or miss type, the breathing through the exhaust pipe will affect the sample if it is not taken at the place noted. The nearer the engine the better in all cases.

The percentage of carbon monoxide in the exhaust will vary widely with different gases and no stated amount will apply for all. A surplus of air as indicated by the appearance of oxygen in the analyzer is the best guide for the engine operator. This insures the conversion of all the hydrogen into water and all the carbon monoxide into dioxide, a condition which is ideal.

J. C. MILLER.

Damaged Gearing

IN HOBBING out a worm gear, does it make any difference if the hob is a little shorter than the worm?

Would this or the fact that it had been running dry cause the gear to become cut up? A. M.

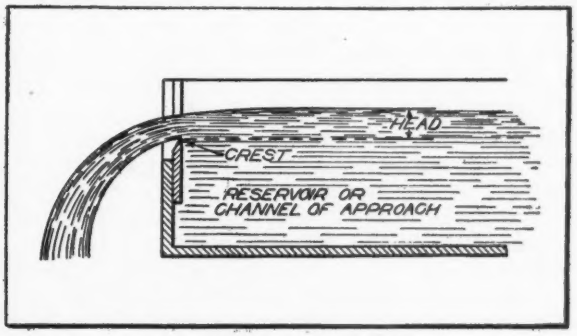
A. In reply to your question, properly the hob should be the same length as the worm which is to run with the gear, otherwise there may be some stock left on the ends of the teeth which will interfere with the worm at the ends.

How much trouble there will be depends on the radius of the gear with respect to the length of the worm. If the hob is as long as that part of the worm which meshes with the gear, there should be no difficulty. Usually the worm extends a little beyond the contact with the gear. If, however, the hob is shorter than the part of the worm which meshes with the gear, there is liable to be some difficulty from interference.

Of course, on the other hand, running any gear system without lubrication will result in cutting, whether the gears are correctly formed or not. A. L. R.

Correction of Weir Construction

ATTENTION has been called by the author to errors in the article on Weir Considerations, page 160 of the February 1 issue. In the sketch, Fig. 3, he should have had the sharp edge of the weir facing the oncoming steam, as shown by the accompanying cut, instead of the



CORRECT POSITION OF WEIR

beveled edge, as was shown. In the third paragraph from the end of the article a typographical error was made, a comma being inserted between the names Hamilton and Smith, which should have been omitted, as this is one man's name.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Some Engine Questions

WHY IS IT that a tandem compound Corliss engine cannot have 2 eccentrics to control low pressure cylinder and 2 eccentrics to handle high pressure cylinder, thereby getting the delicate valve adjustment that can be had with a cross compound?

2. What would be the objection to having crank and crosshead pins made like a ball, so if the shaft got out of line they wouldn't heat?

3. What would be the objection to having crankpin and main journals run in ball bearings, as some of the automobile engines do? F. V. B.

Leakage Through Tunnel Walls

IN OUR establishment we have a tunnel about 1000 ft. long, 6 ft. wide and 6 ft. high, which connects several buildings with the power plant. Its principal use is to carry the steam pipes and electric cables. The floor, walls and ceiling are made of concrete, but I do not know just how thick.

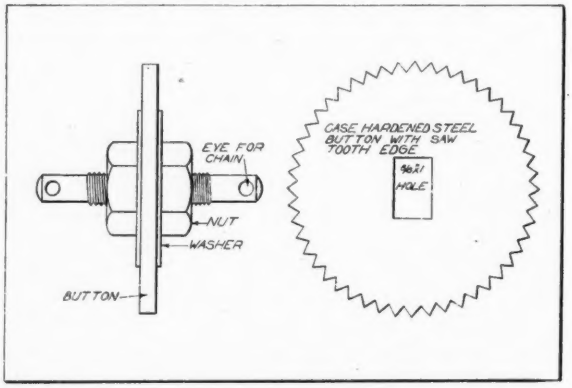
During dry weather this tunnel is dry and may be used in going from one building to the other, but in time of wet weather the seepage through the walls and floor is so great that it cannot be used, and at times there is danger of flooding the entire tunnel system. This tunnel cannot be connected to the sewer, and is drained by means of a siphon or steam pump.

We have tried painting the walls with cement paint, and also several other patented paints that were recommended, but without results. If the cement or tar paint could be applied to the outside of the walls, it might stop the seepage; but this is impossible. If any of the readers of this magazine have ever succeeded in stopping seepage through cement walls I would be pleased to know how it was accomplished. In this case, the leakage is not through large cracks, but through the pores and minute cracks. J. C. H.

Boiler Cleaning Trouble

IN ANSWER to the question asked by L. F. B., in the Jan. 15 issue, as to the best way to clean the circulating nipples and tubes in a B. & W. boiler (the short ones in front are called nipples, while the longer ones in the rear are known as circulating tubes), there are on the market turbine tube cleaners that can be used in the close part of the saddle; but, as there are only 4 or 8 nipples and the same number of tubes that cause this trouble, I would suggest the use of the old style chain and button manner of cleaning.

Get 3 case-hardened saw-tooth buttons made in 3 different sizes, one to be an easy fit in a clean tube, the next 1/16 in. smaller and the last ⅛ in. smaller. If the scale is thick, a button will have to be made the proper diameter to enter this. A ⅝ by 1-in. hole is cut in the center of each button and a bolt threaded in the middle and with an eye at each end, inserted and fastened by means of 2 washers and 2 nuts. The eyes are made by flattening the ends of the iron and drilling the holes. The bolt must be made small enough at the ends so that the nut will pass over. Two pieces of ¼-in. log chain, sufficiently long to reach through the tube far enough that a man can get a good hold of the end, are fastened to the eyes by means of split links.



BUTTON AND LINK SCALE CUTTER FOR WATER-TUBE BOILERS

Drop one end of the chain through and enter the button in the tube. The man on the outside can reach the chain through the handholes and pull the button through. Then he enters the button at the bottom end and the top man pulls it back, and by the use of properly sized buttons the tube may be made as clean as any through which a turbine has been used. A claw bar can be used to pull the chain through link by link, if the button becomes tight, being careful not to break the chain or a tube might have to be taken out.

The buttons should be about ¼ in. thick, and the teeth pointed and sharp. A. G. SOLOMON.

Beading Stirling Tubes; Traps for Hot Water

ABOUT the beaded tubes in the mud drum of a Stirling boiler: the tubes that are beaded are all in one row, which comes in the highest part of the drum, and if they projected through the shell ½ in. would allow the forming of air and steam pockets, therefore every other one is beaded to allow the air and steam to escape. I would like to hear from someone else on the subject.

If G. W. H. can install an improved Bundy trap so that the hot water can flow into it, he will have everything working to suit him. And I would say to L. F. B. that, in a large station where I worked, we had no way to clean the nipples that he speaks of so that after about 10 yr. service they were replaced with new ones.

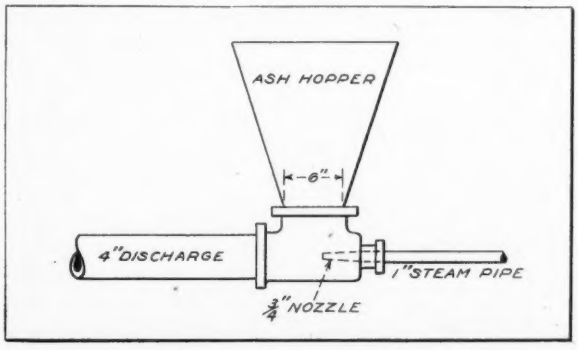
Now, I would be glad to know where LeRoy Blake can find ⅝-in. steam pipe. A. D. W.

Suggestions for Ash Blower

In regard to E. L. Hudson's arrangement for blowing out ashes, I would suggest that he change the location of the steam supply and make the arrangement in the form of an ejector rather than a blower. Connect the steam line to the 6-in. line 20 ft. or even more from the hopper toward the outlet at the rear, preferably in a Y fitting leading to the outlet. Leave the end of the 6-in. pipe fully open; that is, omit the plug with the holes drilled in. It would also be advisable to reduce the size of the opening from the hopper to the 6-in. pipe to about 4 in. This will handle the ashes better than the present layout, provided the ashes are not fed too rapidly to the hopper.

It would probably be better to cut down the size of the hopper to about 1 ft. in height with a platform around it flush with the top, for dumping ashes, and feed by shoveling to the hopper only as fast as they are carried away. Such an arrangement should induce a very strong air current at high velocity through the line, and having the end of the 6-in. pipe fully open to supply as much air as possible and using stated pressure through the proper expanding nozzle to give maximum steam velocity, the ashes should be removed rapidly. It will, however, require frequent renewal of pipe sections, as this, being much on the order of a sand blast, is very hard service to which to subject ordinary pipes. R. S. T.

In reply to E. L. Hudson's complaint, on page 187 of the Feb. 1 issue, regarding his ash ejector which refuses to work, I will say there are several things that are wrong. The first is his bell nozzle. This should be reduced to ¾ in., so as to get as nearly boiler pressure at the tip as possible, thus reducing condensation due to expansion and giving as high a velocity as possible



PROPER METHOD OF CONSTRUCTING ASH EJECTOR

through the discharge pipe. The nozzle should end at about the center of the opening in the ash hopper, so as to avoid steam backing up the hopper. There should be no air inlet except at the hopper.

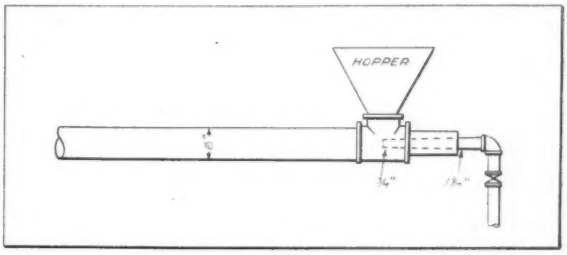
His steam pipe is too small for the size and length of his discharge pipe. He should have at least 1¼ in. steam pipe reduced to 1 in. at the tip. If he will substitute a 4-in. pipe for his 6-in., his 1-in. steam pipe will be large enough for a 20-ft. discharge.

The accompanying sketch will roughly show how it should be made. The steam nozzle should line up centrally with the discharge pipe so the steam will not touch the end of the pipe.

A 6-in. tee reduced to 4 in. on the discharge end and to 1 in, where the steam enters and left full 6 in. to the hopper, will be all right, or if 6-in. on the discharge, a 1¼-in. steam line reduced to a 1-in. nozzle should be used. It is most essential that the nozzle be reduced at least ¼ in.

I wish Mr. Hudson would let the readers hear how he succeeds. S. B. Roper.

Relative to the trouble E. L. Hudson is having with his ash blower, I would advise him to use a 1¼-in. steam pipe for a 6-in. blower, reducing the end of the pipe to ¾ in., thereby forming a nozzle, and increasing the pressure instead of reducing it, as with a bell nozzle.



SKETCH OF A SUCCESSFUL ASH BLOWER

As shown in the accompanying sketch, extend this nozzle nearly to the center of the tee, and a vacuum which will remove the ashes like the shot out of a gun will be created.

Use steam as dry as possible and start the blower before filling the hopper. Geo. H. Worth.

Blowoff Pipe; Threading Brass Pipe

To J. E. K., whose letter was published on page 180 of the Feb. 1 issue, I would say that a blowoff pipe up to the blowoff valve is really part of the boiler and as regards safety must be treated as such. There are 1 or 2 valves, some elbows and tees and considerable length of pipe between the pipe in the combustion chamber and the atmosphere and nothing between it and the boiler, so even with the blowoff valves wide open, the pipe has very nearly boiler pressure on it. It is not possible to let water into a red-hot blowoff pipe "carefully," any more than into a red-hot boiler, even that has been done without an explosion. Also the obstruction might catch again in the valves when J. E. K. can easily imagine what would happen.

As regards threads on brass pipe, keep the dies sharp. It makes very little difference either to the thread or the wear on the dies whether oil is used or not. If they clog and strip, it is probably due to dull or poorly shaped dies. Harry D. Everett.

PRACTICAL ENGINEER

Trade-mark reg. U. S. Pat Office.

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH
At 537 So. Dearborn Street, Chicago, Ill., by the
TECHNICAL PUBLISHING CO.
New York, 150 Nassau St.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Copyrighted, 1915, by Technical Publishing Co.
Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Circulation of this issue, 22,000.

CONTENTS

The Marseilles Development. Illustrated.....247
The Barometer of Power Plant Economy. By Reginald Trautschold. Illustrated 251
Drainage of Low-Pressure Piping. By Charles L. Hubbard. Illustrated 253
Boiler Setting Arches. By Chas. N. Morgan.....255
Characteristic Curves of Centrifugal Pumps. By F. W. Greve, Jr. Illustrated 257
Cost Accounting in Engineering Department of a Modern Hotel. By Newton L. Schloss. Illustrated.....259
Boiler Repairs. By J. Howard Coates.....262
The Interpole Machine. By Gordon Fox. Illustrated...263
Experience in the Operation of Electrical Machinery. By E. C. Parham 265
Choice of Equipment. By Henry B. Jones. Illustrated..267
Use of the Slide Rule. Illustrated.....268
Cooling Towers and Cooling Ponds. By W. G. Stephan.270
Flow of Water in Pipes. By J. W. Ledoux.....271
Letters Direct from the Plant: Tubes and Columns. Friction and Engine Losses. Corliss Engine Cards. The Factory Fire Chief. Wrong Method of Blowing Down Boilers. Reactance Coil Design. Tubes of a Stirling Boiler. Care of Heating System. Repair of Corliss Valve Gear. Feed Water Temperature in Massachusetts. Illustrated 273
Questions Answered and for Answer: Storage Battery Operations. Water Slip in Pumps. Determining Clearance. Proper Gas Engine Fuel Mixture. Damaged Gearing. Illustrated 279
Problems for Discussion by Readers: Some Engine Questions. Leakage Through Tunnel Walls. Boiler Cleaning Trouble. Beading Stirling Tubes; Traps for Hot Water. Suggestions for Ash Blower. Blow-off Pipe; Threading Brass Pipe. Illustrated.....282
Editorial: Buy It Now. Accurate Observation.....284
News Notes 285
Safe Guard Gage Glass Reflector. Illustrated.....286
Development of Power Plant Machinery During 1914. Illustrated 286
New Westinghouse Electric Motor. Illustrated.....288
Revolving Cleaners for Fire Tubes. Illustrated.....288
Books and Catalogs 289
Trade Notes 290

Buy It Now

Not things you don't need, or have no use for, or can ill afford. But, granting that by greater activity and volume of buying, business would be improved, if everybody who needs goods or will need them within a short time, and who can well buy them now, would do so at once, even though the individual orders be not large, the total increase in business would go a long way toward bringing greater prosperity to the country.

Many cities, park boards, and public service corporations are working along this line, and railroads have been placing large orders for material for construction and equipment. The same policy by private corporations, firms and individuals will not only keep mills and factories busy, but furnish work for those seeking it.

What work is there in your plant which ought to be done, and can well be done at once? What personal and family needs must be met soon which can as well be supplied at once? If every man will consider these questions seriously and act accordingly, he will have done his part, and the resulting business improvement will react to his benefit. Waiting for the other fellow to start first never gets anybody anywhere.

Accurate Observation

To the engineer, there is no habit of mind so important as accuracy. Inasmuch as thought is preceded by observation, the foundation for accurate thought is accurate observation. The whole science of engineering is based upon laws of nature which are without error; no leeway is allowed the engineer who wishes to use these laws; he must be accurate in his interpretation of them.

Like all faculties of the mind, accuracy of observation can be cultivated and the more demands placed upon this faculty, the greater will be the ability of the mind in this direction. The greatest development, however, is reached by creating an interest in the things which you desire to observe. The average human is too prone to go blindly past things he should see and know about day after day until by accident or necessity he is forced to see and study them, then too often some "young upstart" has beaten him to it and become master of the situation, and then we complain that we never had a chance.

No practical training is so valuable to a young engineer as an apprenticeship course under a severe master, yet too frequently such a course is nearly so much time wasted, because the mind of the apprentice is directed entirely towards the physical development, while the powers of observation and reason remain untrained.

One of the most exacting tests an engineer has to perform is that of a boiler, and even when conducted under the direction of an engineer trained through years of experience a discussion of the results will invariably bring out points where corrections have been made that are based upon the judgment of the engineer. It is, then, the reputation of the engineer as a careful and accurate observer and thinker that will determine whether or not the test will be considered accurate, regardless of the type, make and accuracy of the instruments used.

Given charge of gang running a heat test of a motor, a young, yet really capable, engineer failed to note in his

instruction sheet that the test was to run for 8 hr. instead of 4 which was customary in commercial tests. When the results were reported to his superior a few minutes after the motor was stopped he learned about his error in no uncertain terms. It was a large motor and the date of delivery was almost at hand with a forfeit attached to the contract. It was fully 6 months before that young man was given another opportunity to conduct even so simple a test as that.

The evil does not stop at the end of a few years of apprenticeship; carelessness or indifference in regard to observing details becomes a habit which should be recognized and "clubbed" every time it shows itself, for it is the great obstacle in the way of the engineer who wishes to succeed.

News Notes

THE AMERICAN DISTRICT STEAM CO., of North Tonawanda, N. Y., announces that it has placed its General Engineering Department under the management of J. G. De Remer, member Am. Soc. M. E., member A. I. E. E., formerly Chief Mechanical and Electrical Engineer of the United Light and Power Co., San Francisco, Cal.

JOHN S. HUEY, formerly with the Allis-Chalmers Co., and more recently with Woodward, Wight & Co., has been appointed by the Kerr Turbine Co., of Wellsville, N. Y., as district sales agent for Louisiana and Southern Mississippi, and will have his headquarters at 418 Hibernia Bank Bldg., New Orleans, La.

THE WESTINGHOUSE ELECTRIC & MFG. CO. announces the removal of the offices of its newly organized Automobile Equipment Department from East Pittsburgh to Shadyside Station, Pittsburgh, Pa., where they will be located in the works devoted exclusively to the manufacture of Westinghouse automobile equipments.

This department was organized on Jan. 1, with G. Brewer Griffin as Manager in charge, and takes the place formerly known as the Automobile Equipment Division of the Detail and Supply Department. The Westinghouse Company reports that the business in automobile equipments has been very satisfactory, thus making it desirable to concentrate the Sales and Works Departments at one point.

In addition to the new headquarters, service stations have been established in New York, Chicago, Indianapolis, Cleveland and Detroit.

COMPETITIVE EXAMINATIONS under the rules of the U. S. Civil Service Commission, for the positions named, will soon be held throughout the United States.

On March 10. 1915: Aid, Bureau of Standards; aid, Coast and Geodetic Survey; apprentice plate cleaner, transferrer, and engraver, Bureau of Engraving and Printing; assistant, Philippine Service (men only); assistant examiner, Patent Office; assistant inspector of boilers; assistant inspector of hulls; computer, Coast and Geodetic Survey (men only); draftsman (copyist topographic—Departmental Service, junior engineer—Engineer Dept. at large, topographic—Departmental Service); Forest Assistant, Forest Service; junior chemist, Departmental Service; laboratory apprentice, Bureau of Standards; land law clerk; local inspector of boilers; local inspector of hulls; matron, Indian Service; pharmacist, Public Health Service; physician, all services, except Panama and Philippine (men only); statistical clerk, Departmental Service; superintendent of construction, Supervising Architect's Office; surveyor, Philippine Service; telegraph operator, Departmental Service; veterinarian.

On April 14, 1915: Agricultural inspector, Philippine Service; aid, Lighthouse Service; apprentice fish culturist; assistant observer (men only); bookkeeper, Departmental Service (men only); cadet engineer, Lighthouse Service; cadet officer, Lighthouse Service; civil engineer and draftsman; computer, Nautical Almanac Office and Naval Observatory (men only); draftsman (copyist, ship — Navy Dept., mechanical—Panama Canal Service, ship—Navy Dept., topographic—Panama Canal Service); engineer, Indian Service; fish culturist; junior engineer (mining), Bureau of Mines; laboratory assistant, Bureau of Standards; library cataloguer; scientific assistant, Department of Agriculture; teacher, Indian Service; trained nurse, Indian Service; wireman.

Application forms and full information in regard to the above-named examinations may be obtained by addressing the U. S. Civil Service Commission, Washington, D. C.

WM. P. COCHRAN, formerly head of the Industrial & Power Department of the Baltimore office of the Westinghouse Electric & Mfg. Co., has been appointed branch manager of the Baltimore office, which has been consolidated with the Philadelphia office of the company. H. H. Seabrook, formerly manager of the Baltimore office, is now manager of the consolidated territory with headquarters at Philadelphia.

Mr. Cochran graduated from Pennsylvania State College in 1898. Upon leaving college he was appointed electrical assistant to the president of the Martic Water & Power Co., of Wrightsville, Pa., which position he retained until 1899. He then entered the Testing Department of the General Electric Co., in New York, where he was employed during the years of 1899 and 1900. In 1901, he entered the employ of the Webster Coal & Coke Co., where he was electrical engineer; then was mechanical and electrical engineer, and assistant general superintendent of the Lackawanna Coal and Coke Co.; succeeding from this position to that of master mechanic for the Pittsburgh-Buffalo Coal Co., at Cannonsburg, Pa., in 1905.

In the fall of this year, Mr. Cochran entered the employ of the Westinghouse Electric & Mfg. Co., being located at Charleston, W. Va., where he remained until the fall of 1910, at which time he left the company and became General Manager and Treasurer of the Kanawha Fire Engine Co., of the same city. After 2 yr., he returned to the employ of the Westinghouse Co. and was assigned to the Baltimore office as manager of the Industrial & Power Division, a position which he retained until his appointment as Branch Manager as noted above.

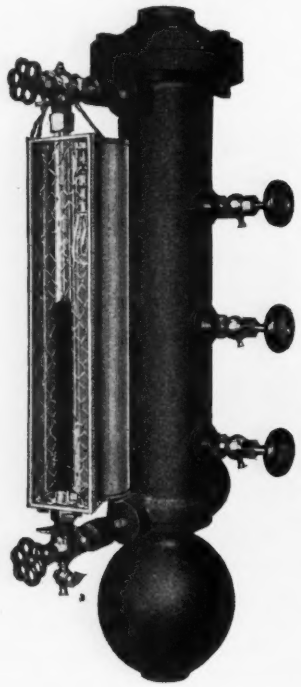
Mr. Cochran has been closely identified with the industrial and power applications, particularly that of the coal mining industry, and has a large circle of acquaintances in the electrical profession who will be glad to learn of his promotion.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Safe Guard Gage Glass Reflector

SAFETY in the operation of a boiler frequently depends upon the ability of the fireman to see at a glance just where the water level stands. This is not always an easy matter, as the gage glass and water are the same color and a slight amount of dirt on the glass may be deceiving. To overcome this difficulty the Reordway Mfg. & Sales Co., of Chicago, has developed what is called the Safe Guard Gage Glass Reflector. It is made of aluminum with a wired glass front and provided with an electric light which so reflects upon the water in the glass as to make it appear red, thus distinguishing positively between that part of the glass which contains water and that containing steam.



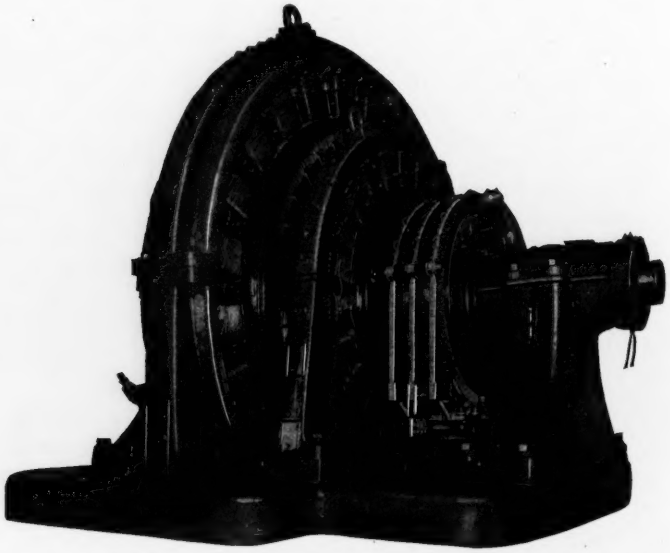
REFLECTOR WHICH MAKES WATER APPEAR RED

The reflector encloses the gage glass entirely, thus keeping it at nearly the temperature of the steam. This reduces the expansion and contraction of the gage glass due to variation of temperature in the boiler room, and also the condensation of steam in the gage glass, these being the 2 principal elements which cause gage glasses to break. The object of the wired glass is to protect the operator from being injured by the breaking of a gage glass.

At both the top and bottom of the reflector there is placed a rubber gasket so arranged that no metal parts touch the water glass. This construction also prevents any leakage from obscuring the transparency of the gage glass. These reflectors are made to fit any standard size gage glass.

Development of Power Plant Machinery in 1914

WHILE some unique developments have characterized the progress in the electrical industry made by the General Electric Co. during 1914, the general advance has consisted largely of improvements in apparatus that had already attained relatively high efficiencies, both electrically and mechanically.



2250-KW. SYNCHRONOUS CONVERTER WITH SYNCHRONOUS BOOSTER

The essential features of the achievements embrace a marked refinement in design resulting in increased efficiencies for many classes of apparatus, economical concentration of large energy values in single machines, and a broadening of the field of application based on experiment and analysis of exhaustive operating data.

Steam Turbo-Generators

EARLY in the year, the first of the large horizontal steam turbine generator sets, consisting of a 20,000-kw. unit, was installed for the Commonwealth Edison Co. of Chicago, and has already been in successful operation for almost a year.

A still larger unit, having an output of 30,000 kw., 6600 v., 25 cycles at 1500 r.p.m. and operating normally under 185 lb. steam pressure, was placed in service by the New York Edison Co. in November, 1914, having been constructed and installed in less than a year, a remarkably short period for a generating set of this capacity.

In striking contrast to the large machines just referred to, is the diminutive turbo-generator developed for supplying current for incandescent headlights and cab lights on steam locomotives. This set has a normal rating of 100 w., 6 v., at 3600 r.p.m., and a maximum continuous capacity of 140 w.

A steam pressure of about 90 lb. is maintained constantly by means of an automatic regulating inlet valve; a pop safety valve is also provided. The turbine is of the single-stage, impulse type, direct coupled to a direct-current, compound-wound generator; and by means of a differential brake magnet coil, any fluctuations in the load are automatically compensated for, so that constant voltage is maintained from no-load to full load.

This little self-regulating set has ample mechanical strength and has successfully withstood severe practical service tests of more than 6 months duration. Its overall dimensions are: length, 23½ in.; width, 15 in.; height, 14¾ in.; and its weight, 130 lb.

Gas-Engine Driven Generators

Due to improvements in design and regulation, the past year has witnessed considerable advance in the use of 60-cycle gas-engine-driven generators; and at the present time, there are nearing completion 3 units of 1390 kv.a. capacity, 2300 v., 60 cycles, arranged for operation at 116 r.p.m. They will be utilized by the Monongahela Traction Co. of Fairmont, West Va., and are the largest 60-cycle generators designed for gas engine drive. Other and larger units had, however, been constructed prior to 1914 for 25-cycle operation, the rating for these machines, which were built for the Bethlehem Steel Co., being 3125-kv.a.

An equitable basis of guarantee for the parallel operation of both gas engine and steam engine-driven generators has been developed by the General Electric Co. which, if generally accepted, should prove of considerable value to the builders of engines and generators, and to the operator.

This guarantee is based largely on the determination of the natural period of the generator in relation to the various characteristics of the complete unit, including flywheel and the operating features of engines and governors, and presents in a logical manner the data necessary for an accurate predetermination of results.

Synchronous Converters

The advance in this class of apparatus has been marked chiefly by the increased unit capacity produced in 60-cycle machines. A representative installation consisting of 2 2250-kw., 225/275-v. converters equipped with synchronous boosters has been constructed for the Boston Edison Co. These machines have approximately 50 per cent greater capacity than any 60-cycle machines of this type heretofore developed, and their successful operation has resulted in the adoption of still larger units.

The equipment of synchronous converters with synchronous boosters, which are integral parts of the complete machine, together with the arrangement of wattmeter control, constitutes a most important improvement in synchronous converter operation and insures a positive and automatic adjustment of the direct-current voltage. This is accomplished through control of the field excitation of synchronous converters provided with commutating poles. It insures correct excitation at all loads and voltages instead of a step-by-step correction, which has heretofore been necessary. The new system obviates the use of contactors in combination with a number of resistance steps, which were formerly required, and has been applied with entire success during the year to both 25 and 60-cycle units of the synchronous booster type.

Synchronous Condensers

A horizontal shaft 6000-kv.a., 50-cycle, 500-r.p.m. synchronous condenser constructed for the Southern California Edison Co. of Los Angeles, is of unusual interest due to the fact that it was designed for operation on a 16,500-v. line, no machines of this type having been previously built for potentials exceeding 6600 v.

In addition to the precautions necessary for insulation against this unusual potential, special efforts were made in designing the machine to minimize the losses; and as a result, there was produced a synchronous condenser of very high efficiency, utilized solely for power factor correction. It is self-starting by means of a compensator and requires less than half its rated kilovolt-amperes for starting.

Prior to 1914, the largest core type transformers produced by the General Electric Co. did not exceed 2000 kv.a. in rated capacity, but during the year the maximum rating was carried up to 7500 kv.a. The maximum rating of single-phase water cooled, shell type transformers has also been increased by the construction of 4 units of 8333 kv.a. capacity.

There has been a marked reduction in interruption to service in transformers of recent design, as they are now capable of withstanding momentary short circuits under sustained primary voltage without injury to the coils. This has been accomplished largely through changes in the grouping of the coils and working to higher inherent reactance.

A feature of unusual interest for the year is the development of a combination transformer which may be operated either self-cooled or water-cooled. It may be designed for normal operation with water circulated through the cooling coils, in which case, it may also be safely operated at 50 per cent of normal load without the circulation of water and without exceeding its specified temperature rise. On the other hand, this transformer may be designed for normal operation as a self-cooled unit, and be provided with the necessary cooling coils, which, when utilized, permit operation efficiently at 50 per cent above the normal capacity. The economical advantages of such transformers are obvious, especially for localities where the purchasing rate of water is high and the transformer is fully loaded only part of the time. This design also provides a factor of safety in case of interruption in the water supply, in which event the apparatus may still be operated at partial load instead of being shut down.

New Westinghouse Electric Motor

THE Westinghouse Electric & Mfg. Co. has recently placed on the market a new line of large slip-ring induction motors for continuous service, such as driving pumps, blowers, compressors, hoists, and other machinery requiring heavy starting torque.

One of the chief characteristics of these motors is great strength. The frame is massive, the bearings and shaft extra large, and the windings are securely braced against vibration. The bearings are dustproof and rest on 3 machined seats, a construction found to be the

SLIP-RING INDUCTION MOTOR FOR CONTINUOUS SERVICE

best practice in steel-mill service. The bearing shell may be removed and replaced without taking off the lower half of the bearing bracket.

All coils are form wound and completely insulated to ground before being placed in the slots. The stator slots are straight open, while those of the rotor have an overhanging lip which assists in holding the coils in place, although the coils may be removed and replaced without bending as readily as with straight open slots. The shaft can be removed without disturbing the rotor winding.

Revolving Cleaners for Fire Tubes

TO avoid any misconception as to the availability of rotating cleaners for fire-tube boilers, the following descriptions are presented of 2 cleaners of this type, as additional to the treatment of the subject in the Jan. 1 issue. The first, shown in Fig. 1, and made by the Liberty Mfg. Co., of Pittsburgh, Pa., consists of an air motor with hardened steel cylinder containing an eccentrically mounted shaft in which a pair of semi-balanced blades reciprocate in a longitudinal slot. The spear-shaped head has a universal joint and it is stated that, due to this special form of drill and joint, a combined rotating and gyrating effect is produced, resulting in the tool never striking twice in the same place, thus covering all points of the tube.

In Fig. 2 is shown a cleaner consisting of an air or steam driven turbine and knocker head. The motor is of the rotary engine type having 4 paddles, 2 of which are always under pressure.

As shown, the knocker head is made of 3 parts; a cylindrical body somewhat smaller in diameter than the boiler tube and an eccentrically pivoted lever carrying a clover shaped knocker on a stud at its free end.

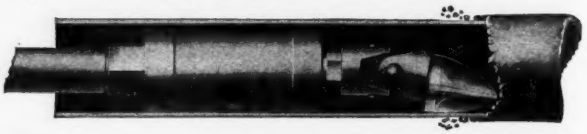


FIG. 1. ROTARY TUBE CLEANER WITH UNIVERSAL JOINT AND SPEAR-SHAPED HEAD

The head is driven at high rotative speeds; the eccentrically pivoted lever carrying the knocker is thrown from side to side and the knocker caused to revolve on its

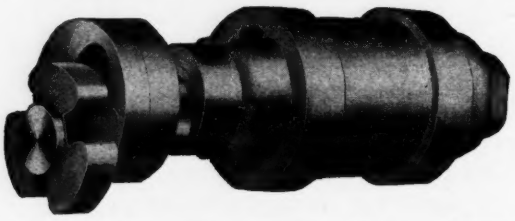


FIG. 2. VIBRATOR HEAD ATTACHED TO AIR OR STEAM DRIVEN TURBINE

axis at each contact with the tube, giving a resultant gyratory motion to the knocker, causing it to strike all points of the interior circumference of the tube.

This turbine tube cleaner is manufactured by the Lagonda Mfg. Co., of Springfield, Ohio.

THE TECHNICAL SUCCESS of the International Engineering Congress, to be held Sept. 20-25, San Francisco, is now well assured. Notwithstanding the difficulties arising as a result of the present European war, the Committee on Papers is able to count on from 200 to 250 papers and reports covering all phases of engineering work and contributed by authors representing some 18 different countries. The Congress will therefore be truly international in scope and character.

Papers are now rapidly coming in and their character gives the fullest assurance that the proceedings will form a most important collection of engineering data and a broad and detailed review of the progress of engineering art during the past decade.

The Committee of Management is now issuing to all important engineering societies, in this country and abroad, invitations to appoint official delegates to attend the sessions of the Congress, and the presence of a considerable body of such delegates is well assured.

Membership in the Congress with the privilege of purchasing any or all of the volumes of the proceedings is open to all interested in engineering work. For full particulars apply to W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Cal.

THE KERR Turbine Co., Wellsville, N. Y., has appointed W. E. Storey as its Toronto, Canada, representative, with offices in the Kent Building. Mr. Storey was formerly identified with the Underfeed Stoker Co., and more recently with Goulds Mfg. Co.

Books and Catalogs

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK FOR 1915. Twenty-eighth year of publication, 438 pages, illustrated; Manchester, Eng., 1915. Price, $.50 prepaid.

This, as previous editions, contains a large collection of notes, rules, data, and tables of value to mechanical engineers, draftsmen, mechanics and students.

New sections have been added on structural iron and steel work, the strength of flat plates, limit gages, cost of power, proportions of tee slots, Morse tapers, etc.

Various tables have been extended and the sections on gas engines, oil engines and suction gas producers have been considerably revised.

THE "MECHANICAL WORLD" ELECTRICAL POCKET BOOK FOR 1915; 302 pages, illustrated; Manchester, Eng., 1915. Price, $.50 prepaid.

The contents of this companion volume to The "Mechanical World" Pocket Diary and Year Book, include a varied collection of electrical engineering note, rules, tables and data, specially prepared for the use of those in charge of electrical machinery and apparatus.

New sections are given on electric circuits and switching, synchronizing and alternating-current generator and motor troubles. The section on the application of electricity on shipboard has been rewritten and extended while additions have been made to those sections dealing with the use of electricity in coal mines, motor starters, etc. The matter on Dynamo and Motor Defects has been revised and condensed, while the sections on Electric Lamps and Electric Lighting have been brought up to date.

BULLETIN No. 55 of the McIntosh & Seymour Corporation, Auburn, N. Y., is devoted to a discussion of complete Diesel type oil engine power plants. After a brief mention of those accessories which are always furnished with these engines and those plant accessories the company is prepared to furnish, descriptions of the engine proper, their foundations, fuel oil tanks for immediate supply and the fuel oil storage tanks are given. The last 6 sections of this bulletin are devoted to the engine-room piping, exhaust silencer, cooling water, necessary arrangements of the plant to allow for convenient erection and repair, lubricating oil storage tank and filter and the proper equipment of repair parts, necessary tools, cleaning materials, wrench board and work bench.

Various illustrations showing the Diesel engine in process of manufacture, the complete engine and the engine in operation together with a plan and cross-sectional drawings of a typical power plant arranged for a 90-hp. Diesel type oil engine and accessories are shown.

FROM CHARLES JACOBS & CO., 258 Franklin St., Boston, Mass., we recently received a circular illustrating the Jacobs water tube feed water heater and purifier, the Lowden grease, oil and grit extractor for separating and automatically discharging grease, oil and grit from exhaust steam, and the Lowden automatic water separator for separating and automatically discharging entrained water from live steam.

THE ENGINEERING DIRECTORY for 1915 contains new features of interest to manufacturers of engineering, mill and machinery supplies. It is divided in such a way that the selling, or mailing lists are contained in Part I, while the buyers' section, or classified directory of manufacturers, is contained in Part II. Those who are interested in the selling section only, may purchase Part 1 at the regular price of $5; or both parts together at $6, prepaid.

The Engineering Directory is published by the Crawford Publishing Co., 537 South Dearborn St., Chicago, Ill.

CHAS. A. SCHIEREN CO., New York, manufacturer of Duxbak belting, is distributing a map, 2 by 3 ft. in size, showing the steamship routes of the world. It also shows the distances between the various ports on each route and gives other appropriate information, all in convenient tabular form. This map is well executed, in 2 colors, and we presume that copies of it may be had by Practical Engineer readers on application, without charge, if the edition is not exhausted.

A NEW CATALOG just issued by Alberger Heater Co., Buffalo, N. Y., covers heaters, not only for feed water purposes, but for hot water service or domestic supply, as used in hospitals, hotels, etc.; also for oil coolers, oil heaters and air coolers. The Ross expansion joint, the primary feature of which is guiding the pipe line, for securing perfect alinement with that part of the piping which is held rigid, the object being to prevent the ordinary wear and tear on packing, is described.

BULLETIN No. 49,901, just issued by the General Electric Co., describes an oil-testing set, by means of which the dielectric strength of oil can be easily determined. The proper use of this set insures the successful operation of high tension oil insulated apparatus. The set consists of a 30,000-v. testing transformer with an induction regulator for voltage control and an oil spark gap, all of which are assembled as a unit. The set can be furnished for either 25 or 60 cycles.

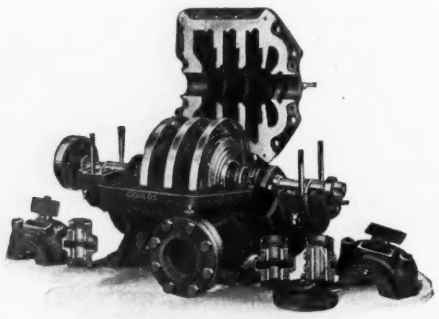
S. & K. HEAT TRANSMISSION apparatus for heating and cooling water and gases, and cooling oil, is the subject of a recent publication of Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia.

Trade Notes

THE PATENT SUIT brought against the B. F. Sturtevant Co., of Boston, by the Sirocco Engineering Co., which has been in the courts for the past 6 yr., has just been decided by the United States Circuit Court of Appeals for the Second District in favor of the Sturtevant Co.

It was claimed that the Sturtevant Multivane Fan infringed the Sirocco Co.'s patents, and in the lower court this claim was sustained. The Court of Appeals, however, reversed the former decision and held that there was no infringement. The Court of Appeals further decided that the Sirocco patents in suit were void in view of the development of the fan building art prior to the alleged inventions upon which these patents were based.

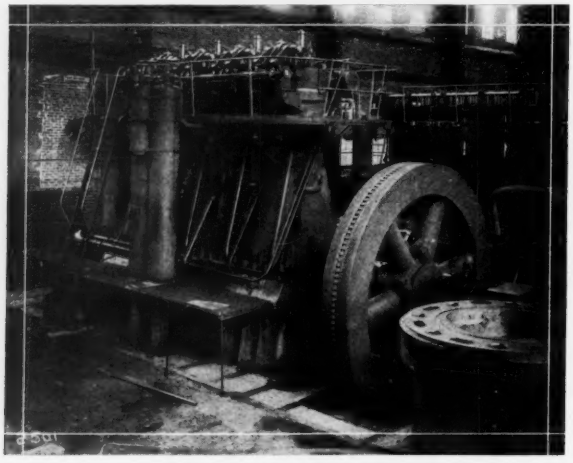
THE GOULDS MANUFACTURING CO., of Seneca Falls, N. Y., has recently placed on the market a new line of multi-stage centrifugal pumps for installations where the head is greater than can be efficiently dealt



with in a single stage. The pump casing is divided horizontally and is provided with single suction. The pumps range in capacity from 200 to 1500 gal. per min. at a maximum head of 700 ft. The illustration shows the 3-stage type with top half of casing removed.

SOME REASONS why the mechanical goods of the Goodyear Tire & Rubber Co. are occupying a large place in the field are, as stated by I. R. Bailey, Sales Manager of the company, as being the long experience and the kind of men who have control of the product. In this department are 21 men, one of whom has had 27 yr. of experience, and the average experience being 6 yr. These men direct the department, and in no instance do they build a product to "meet the price," but purely for service standards. The effort is always to furnish an article to meet a specific need, and to do its appointed work in the best way possible.

AT THE WORKS of the McIntosh & Seymour Corporation recently 5 Diesel-type oil engines were in course of erection, three of these are shown in accompanying cut. Each of these sets develops 500 b.hp. from



4 cylinders and it is a set of this character which will be shown running at the Palace of Machinery, Panama Pacific Exposition, where one of the same company's smaller high-speed sets will also be exhibited.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

SEMI-MONTHLY

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH.

Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.

In Canada, subscription price, $1.75 a year.

Foreign Countries, subscription price, $2.50 a year.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 So. Dearborn St., Chicago, Ill.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.

ADVERTISING RATES

Display

Full page, one year, each insertion, $60.00.

Half page, one year, each insertion, $35.00.

Quarter page, one year, each insertion, $20.00.

Eighth page, one year, each insertion, $12.00.

Front cover, $150.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,500

Technical Publishing Co.
537 S. Dearborn Street
Chicago

Position Wanted

POSITION WANTED—Experienced engineer who understands both theory and practical operation of generators, steam and gas engines, and water purification, with technical education and 9 yr. practice in all lines, desires position in Middle West. Will furnish best of references, including present employer. Address Box 383, Practical Engineer, Chicago, Ill. 3-1-1

POSITION WANTED—As Chief Engineer in a hotel, office building or manufactory. Experienced in power refrigeration and hydraulics. Address Box 386, Practical Engineer, Chicago. 3-1-1

POSITION WANTED—Graduate in Electrical Engineering 1914, desires work with some power and light company or electrical contractor. Have had some experience. Can give best of references. Address Box 207, L. T. P., Wilsonville, Nebr. 3-1-1

POSITION WANTED—By engineer with 10 yr. experience on Corliss and slide-valve engines, horizontal and vertical water tube boilers. Age 40 yr. Address Ed Larson, Aetna, Ind. 3-1-1

POSITION WANTED—By Sales Engineer with wide experience in selling Steam Engines, Boilers and Power Plant Equipment. Have shop experience and technical education. Can produce results. Address Practical Engineer, Box 379, Chicago, Ill. 2-15-2

POSITION WANTED—By a young man at present holding a first-class fireman's license in Massachusetts. Understands repair work thoroughly. Will go anywhere in Middle West or Eastern states. Married, and can furnish best of references. Address Box 382, Practical Engineer, Chicago, Ill. 3-1-1

POSITION WANTED—In a modern plant where knowledge may be acquired. 3 yr. experience as fireman, oiler and switchboard operator. I. C. S. student. 30 yr. of age; married; abstainer and dependable. F. W. Beecroft, 3216 Fulton St., Chicago, Ill. 2-15-2

POSITION WANTED—By young man, age 21, as oiler or helper in power plant. A. S. C. graduate, electrical course. Some experience small gas engines. Would work a while for experience. Address O. W. House, Rush Springs, Okla. 2-15-2

POSITION WANTED—By engineer with years of experience in Ice and Electric Light Plants. Understand both A.C. and D.C. machines. Am a graduate of one of the best colleges in Middle West. A1 references. Ezra D. Dumas, Clarinda, Iowa. 3-1-1

POSITION WANTED—By student, fresh from University of Engineering. Desirous of getting into Mechanical, Electrical or Architectural Engineering. Some experience. Address A. W. Kelly, 5531 Lakewood Ave., Chicago, Ill. 2-1-3

POSITION WANTED—By younug man, age 22, as Oiler or Assistant Engineer. I. C. S. graduate, Steam-Electric course. 4 yr. experience as quarry Hoisting Engineer. Good reference. Oscar Malila, Troy, N. H. 2-15-2

POSITION WANTED—By young man, as wireman; 5 yr. experience. Reference. Can come March 1. Harold Howes, Williams, Iowa. 2-15-2

Wanted

FREE ENGINEERING BOOKS and power plant tools and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill. tf.

WANTED—Resident subscription agents in all cities of 50,000 population, and over. Many of the largest cities still open. An excellent chance for hustlers to turn their spare time into dollars. Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Agents to sell my Graduated Calipers, Pocket Levels, etc. Liberal commission. Ernst G. Smith, Tampa, Fla. 2-1-6

Help Wanted

SALESMEN WANTED—Experienced, in every large city and territory to handle Vacuum Traps and High Pressure Expansion Traps. State full particulars in answer. Address Box 387, Practical Engineer, Chicago. 3-1-2

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

For Sale

FOR SALE—Grobet Swiss Files are the standard of excellence in files, and have been for over 100 yr. We send, post paid, as an introducer, 48 files especially adapted for tool makers and machinists on receipt of $5.00. This is a chance to get a set of files you'll appreciate and we'll get future orders. Montgomery & Co., 101 Fulton St., New York, N. Y. 3-1-1

FOR SALE—Specials: 18x42 Lane & Bodley Corliss engine, 2 yr. service, $450. Three 72 in. by 18 ft. HRT boilers, 150 lb. steam pressure, 2 yr. service, $400 each. 500-hp. Haine water-tube boiler, 6 yr. service, 150 lb. steam pressure, $1675. 75-kw. Northern 230-volt generator, direct-connected Erie Ball engine with switchboard, $1000. Duzets & Son, 50 Church St., New York. tf.

CARR VENTILATED FURNACE ARCH for all types of boilers and furnaces, gives 100 to 400 per cent greater service than any other kind. Write for information, giving number and kind of boilers and furnaces. Elmer E. Carr, 231 Insurance Exchange Bldg., Chicago, Ill. 3-1-3

FOR SALE—Steam Hammer, 750-lb. Bement Niles; excellent condition; will sacrifice to move quick. Have large stock machinery of all kinds. Send us your inquiries. Zelnicker Supply Co., St. Louis, Mo. tf.

FOR SALE—10x12, steam-driven air compressor, designed for high pressure work on air or gas. Write for details. Lucas & Son, Bridgeport, Conn. 3-1-2

Patents and Patent Attorneys

PATENTS SECURED OR FEE RETURNED—Send sketch for free search, advice and report. Latest and most complete patent book ever published for free distribution. George P. Kimmel, Attorney, 226 Barrister Bldg., Washington, D. C. 12-15-6

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Bldg., Washington, D. C. tf.

PATENTS THAT PROTECT AND PAY—Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for free search. Watson E. Coleman, Patent Lawyer, 624 F St., Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact costs. Send for full information. tf.

PATENTS—Send sketch for free search and report. Books on patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Technical Books

ENGINEERS AND FIREMEN—Send 10c in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2238 Pope Ave., St. Louis, Mo. 10-1-6

Educational and Instruction

ENGINEERS' POCKET MANUAL, 175 pages, edited by University of Tennessee, will be mailed every subscriber sending in NEW subscriptions (not your own) to Practical Engineer. Gilt edges; bound in leather. tf.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

President Wilson pressed the button at Washington. Waves of electric energy sped through miles of space.

The radio-harp on the top of the "Tower of Jewels" at the other extreme of the Continent received the signal and the doors of the palaces of a great exposition were thrown open and the machinery in one of the largest wooden structures of the world—The Palace of Machinery—was set in motion.

It is the greatest exposition in history, to commemorate the completion of the greatest physical achievement in engineering—the Panama Canal—that Herculean task that marks an epoch in the history of the world.

Congress entrusted to California, the responsibility of designing and constructing an exposition to celebrate and do justice insofar as possible to so great an achievement.

lously, from the "Tower of Jewels," swaying with the slightest wind or jar, flash and scintillate as myriads of diamonds and vari-tinted jewels, setting the sky ablaze at night.

The Palace of Machinery contains exhibits of machinery and accessories used in the generation, transmission and application of power from the toggle bolt to the turbine.

And yet with all these wonders that would have caused P. T. Barnum's Press Agent to exhaust his supply of adjectives, where would the exposition be without the publicity accorded it?

It would have had as much chance of success as a department store in the stone-age.

Publicity blazed the trail to the exposition. Publicity blazes the trail to knowledge. It is an educative force. How deeply indebted to the press is the general

PALACE OF MACHINERY

So with the sparkling sapphire waters of the Bay of San Francisco—with the haughty surrounding mountains and the still more haughty Tamalpais—with the turquoise sky of California and the iridescent sun-rays of "the Golden West"—with the rolling emerald hills 'midst the "garden of the earth"—with the ideas of the architectural genius, the famed artist, the skilled gardener and illuminating engineer—with all this natural, scenic beauty and the dreams and accomplishments of science and art, Man harmonized and constructed an exposition, the beauty of which will live in the memory of the beholder as long as memory itself endures.

Such is the Panama-Pacific International Exposition.

Editors and magazine contributors have written reams of copy describing its wonders. Not a trade journal, magazine or newspaper could be found that has not mentioned its lavishness of construction—its color schemes by day—its illuminating effects by night.

Thousands of hand-cut glass prisms hung tremu-

public for the opportunity of reading of the exposition, —of California, and of the places en route. How the reader has broadened his intellect—his knowledge geographically, topographically, agriculturally and otherwise of the land that lays to the west. He has received accurate visual impressions through the printed pictures in the advertising of the exposition company and other interested beneficiaries.

No man with eyes and a sound mind, though he live in a two-by-four village, has an excuse for not knowing something of the exposition and the western states.

Nor should any engineer of today be lacking in knowledge of the apparatus in his line that is brought to light through the advertising page.

He who advertises his product does not "hide his light under a bushel basket," hence he is not ashamed of it and knows it must be right, which leads us to say—

To broaden your mental horizon, read the advertisements you see herein. To be on the safe side, buy the products advertised.